Teaching Chemistry to Students with Disabilities, 5th edition

A product of the ACS Committee on Chemists with Disabilities

Editors: Patricia Redden, Carl Heltzel, Debra Feakes, Michelle Cummings, and Theresa Windus

Important Note:

This eBook should not replace the guidance provided by educational institutions. Please consult with your institution's special education director at the secondary level or the Office of Disability Services at the postsecondary level to ensure compliance with applicable laws and regulations,

Acknowledgement

This eBook has built on the previous versions of the “Teaching Chemistry to Students with Disabilities, and the authors and editors of this version wish to acknowledge all the work of the previous authors and editors. Unfortunately, the names of all the previous authors are not available. While there is a list of authors in version 4.1, there were others who contributed to other versions as well, and many members of the American Chemical Society’s Committee on Chemists with Disabilities have been involved. To those that have contributed to previous versions (and, therefore, directly, or indirectly to this version), we give our greatest appreciation. We also thank the editors from the 4th edition (2002) - Dorothy L. Miner, Ron Nieman, Anne B. Swanson, Kelley Carpenter, and Michael Woods - and from the 4.1 edition (2015) - Todd Pagano and Annemarie Ross.

We also thank all of those who have been involved in the current version of the eBook. Unsung heroes who helped with the organization of the work and in keeping the work on track include Paula Christopher, Sara Spiro, James (Jay) Schiller, and Michelle Cummings.

Important Note: 2
Acknowledgement 2
Chapter 1: Introduction 7
1.1. Some Statistics 7
1.2. Practical information for Classroom and Lab 9
1.3. It's the Right Thing to Do 10
1.4. It's the Law 11
1.5. Inclusion versus Full Participation 11
1.6. Strategies, Methods, and Resources 12
1.7. Assessing the Success of Accommodations 12
1.8. Effect of the COVID-19 Pandemic on SWD Learning and Education 13
1.9. In summary 13
1.10. References 14
Chapter 2. Disability Laws and Services 15
2.1 Introduction 15
2.2 Rehabilitation Act of 1973 16
2.3 Individuals with Disabilities Education Act (IDEA) 17
2.4 Americans with Disabilities Act (ADA) of 1990 19
2.5 Institutional Responsibilities 20
2.6 Faculty Responsibilities in Higher Education 22
2.7 Student and Faculty Responsibilities Working with the DSS Office in Higher Education 24
2.8 Disability Harassment 26
2.9 References 27
Chapter 3: An Overview of Accommodations 30
3.1 Introduction 30
3.2 Equity 32
3.3 Disability Support Services 35
3.4 At the Beginning of the Semester 35
3.5 Considerations during the Semester 37
3.6 Taking Notes 40
3.7 Testing and Evaluation 40
3.8 **Past Accommodations as a Guide** 42

3.9 In the Laboratory 43
3.10 References 47
Chapter 4: Universal Design: Accessibility for Everyone 49
4.1 Introduction 49
4.2 User-Friendly Emphasis 53
4.3 Universal Design for the Classroom 54
4.4 Universal Design for the Lab 55
4.5 Universal Design for the Internet and Electronic Media 59
4.6 Electronic Resources for Teaching 62
4.7 References 66
Chapter 5: Service Animals 69
5.1 Definition of a Service Animal 69
5.2 Access Rights 70
5.3 Considerations in the Classroom 72
5.4 Considerations in the Laboratory 72
5.5 Conclusion 77
5.6 References 77
Chapter 6: Transitioning from High School to College 79
6.1 Introduction 79
6.2 The Journey to a Career in Chemistry 80
6.3 Acquiring Skills 82
6.4 Moving on to college 83
6.5 Internships 84
6.6 Awareness of and Understanding the Law 84
6.7 How to Be Successful: Persistence, Resilience, and Making Use of Resources ... 85
6.8 The DSS Office 86
6.9 The Importance of Self-Advocacy 87
6.10 Mentoring Students with Disabilities 88
6.11 College to Graduate School or Employment 89
6.12 Employment 90
6.13 References 91
Chapter 7: Blind and Low Vision 92
7.1 Range of Needs 92
7.2. Accessibility Guidelines 94

7.3 Classroom Considerations and Adaptations 95
7.4. Testing and Evaluation 102
7.5. Laboratory Considerations and Adaptations 103
7.6 Assistive technology and Accessible Computing 105
7.7 Conclusion and Outlook 109
7.8 References 110
Chapter 8: Students Who Are Deaf or Hard of Hearing 117
8.1 Introduction 117
8.2 Range of Needs 118
8.3 Accessibility Guidelines 119
8.4 Classroom Considerations 119
8.5 Testing and Evaluation 125
8.6 Laboratory Considerations 126
8.7 Assistive Technology 128
8.8 Conclusion 131
8.9 References 131
Chapter 9: Communication Impairments Stephanie A Hall*,[1] and Kathleen H. Palatucci*,[2] 134
9.1 Range of Needs 134
9.2 Accessibility Guidelines 136
9.3 Classroom Considerations/Adaptations 136
9.4 Testing 137
9.5 Laboratory Considerations/Adaptations 138
9.6 Assistive Technology 138
9.7 Considerations for Distance Learning 139
9.8 Summary 139
9.9 References and Resources 139
Chapter 10: Mobility and Fine Motor Skills Impairment Patricia Ann Redden 141
10.1 Range of Needs 141
10.2 Accessibility Guidelines 143
10.2.1 Evaluation of Needed Accommodations: 144
10.3 Classroom Considerations and Adaptations 145
10.4 Testing 146
10.6 Assistive Technology 151
10.7 References 151

Chapter 11: Teaching Students with Learning Disabilities 154
11.1 Range of Needs 154
11.2 Classroom Considerations and Adaptations 158
11.3 Testing 159
11.4 Laboratory Considerations and Adaptations 159
11.5 Assistive Technology 160
11.6 References 161
Chapter 12: Invisible Disabilities and Chronic Illness 166
12.1 Introduction 166
12.2 Range of Needs 167
12.4 Classroom Considerations and Adaptations 183
12.5 Testing 186
12.6 Laboratory Considerations and Adaptations 188
12.7 Assistive Technology 190
12.8 Acknowledgements 192
12.9 References 192
In Conclusion 196

Chapter 1: Introduction

Carl Heltzel

**Associate Professor, Medical University of South Carolina,
Director for Research Development and Senior Science
Writer, Hollings Cancer Center, Charleston, SC 29425
Email: heltzel@musc.edu**

Chapter 1 Contents

1.1. Some Statistics
1.2. Practical information for Classroom and Lab
1.3. It's the Right Thing to Do
1.4. It's the Law
1.5. Inclusion versus Full Participation
1.6. Strategies, Methods, and Resources
1.7. Assessing the Success of Accommodations
1.8. Effect of the COVID-19 Pandemic on SWD Learning and Education
1.9. In summary

1.1. Some Statistics

Individuals with disabilities, whether visible or not, and possibly based on physical or emotional/learning issues, often encounter barriers to one of modern society's most important rites of passage. It is that crucial process of obtaining a good education—often natural and uncomplicated for most people—that opens the door to productive employment and full participation in society. Today's barriers are less often physical or architectural. More often, they involve perceptions and misperceptions of not just disability but also ability. One misperception is that a disability somehow disqualifies a person from a career in science, technology, engineering, or mathematics.

Well-intentioned but misinformed adults still discourage students with disabilities from pursuing careers in these fields. Often it occurs indirectly and implicitly, when adults withhold the mentoring and encouragement that can nudge young people toward science careers and sustain their interest. In addition, adults may set artificial limits on what the student with a disability should attempt. These limits may not be based on reality, but instead focus on the adult's own low expectations for the student or their sincere concerns that the student may fail and not cope well with failure. In reality, students with disabilities benefit from the freedom to establish their own horizons;[1] they cope very well with the process and learn from each opportunity. When students make use of various resources to accommodate specific learning needs, they can excel in classroom environments, especially chemistry courses.

In 2018–2019, the number of students ages 3–21 who received special education services under the Individuals with Disabilities Education Act (IDEA) was 7.1 million, or 14% of all public-school students. Among students receiving special education services, 33% had specific learning disabilities.[2]

College is normally an exciting time for incoming students, but for those with disabilities, anxiety may prevail. Having to engage with higher education faculty while beginning more complex coursework can overwhelm a student without the proper support. In terms of college preparation, where about 12% of secondary school students have a disability, only 1% of these students are enrolled in advanced placement courses. Consider the process as students transition from high school to college: 94% of high school students with learning disabilities receive some form of learning assistance. In contrast, only 17% of college students with learning disabilities make use of learning assistance resources. The abrupt end to a student's structured assistance may leave the student feeling vulnerable and alone.

For the 2018–2019 academic year, there were 21.0 million undergraduate students enrolled in U.S. institutions of higher education. In the fall of 2019, 21% of these students had reported a disability of some kind; Table 1 provides a breakdown of some of these disabilities.

Type of Disability	Percent of Undergraduate Students
ADHD	9%
Blind/low vision	3.8%
Learning disability	3.6%
Deafness/hearing loss	2%

Table 1. Breakdown of Undergraduate Students by Type of Disability[3]

Self-advocacy is key for students with disabilities (SWD) if they desire to successfully complete a college degree. Degrees in Science, Technology, Mathematics, and Engineering (STEM) are no exception. Students must be encouraged and supported to advocate for themselves in various academic settings. Faculty and staff as well as a student's peers should fully support SWD as they seek solutions. It is important for the entire institution to show that everyone is diverse in multiple ways and that strategic and specific actions are being taken – involving students in this process – to reduce any stigma related to learning and other disabilities. Oftentimes, students might seek support and accommodations with an almost combative-type attitude, which may not serve the student or the institution well. A member of the ACS Committee on Chemists with Disabilities, Dr. Hoby Wedler, stated,

> "*Many students with disabilities seeking accommodations at their high school or college tend to do so forcefully, but my advice is to do it instead with Zen and pizazz. A calm, almost meditative way of bringing people together is more effective*."

Dr. Wedler should know; he earned a Ph.D. in organic chemistry from the University of California, Davis – even though he has been totally blind since birth.

Students with disabilities are entering post-secondary education programs in numbers that are higher than ever. A study by the American Council on Education (ACE), for example, revealed that first-year college students with disabilities express just as much interest in pursuing a science major as their able-bodied peers. Unfortunately, students with disabilities have much higher rates of dropout than their counterparts. A National Center for Education Statistics (NCES) report found that only 34% of students with disabilities had completed a four-year degree eight years after their high school graduation.

Study after study verifies the existence of lack of encouragement. Despite the American with Disabilities Act (ADA) and many advances and individual success stories, people with disabilities remain the most underemployed and unemployed group in society. In 2019, 19.3% of persons with a disability were employed. In contrast, the employment–population ratio for persons without a disability was 66.3 percent.[4] Today's global economy and the surge of technology are increasing the demand for qualified persons with STEM skills. The recognition of the value that diversity brings to innovation makes persons with disabilities – in both academia and industry – an ideal source for filling this demand.

The American Chemical Society (ACS) has pioneered efforts to remove barriers that hamper individuals with disabilities from studying chemistry and starting careers in science. ACS, the world's largest scientific organization, focuses its efforts through its national Committee on Chemists with Disabilities (CWD). The committee's projects include four previous editions of this book, which were entitled *Teaching Chemistry to Students with Disabilities*. Throughout this book, it will be referred to as *Teaching Chemistry*. A companion publication, *Working Chemists with Disabilities*, describes how scientists maintain productive careers in research, teaching, and other fields despite physical disabilities. NSF generously funded work on *Teaching Chemistry*. The ACS also recently published a Symposium Series book on removing barriers in the laboratory, titled *Accessibility in the Laboratory*.[5]

1.2. Practical information for Classroom and Lab

Teaching Chemistry is a resource book for teachers at the high school, technical college, college, and postgraduate levels; students with disabilities; parents; counselors; and professional staff in college Disability Services for Students (DSS) Offices (or similarly named offices that will be referred to in this resource as the DSS office). Since the publication of the initial edition in 1981, ACS has distributed thousands of copies of the first four editions of *Teaching Chemistry* without charge in the United States and other countries. *Teaching Chemistry* is widely recognized as a source of practical information on how to promote full participation of students with disabilities in the classroom and laboratory.

Prepared by scientists who themselves have excelled in chemistry despite various disabilities and by experts on disability issues, the book is noted for its sensitivity to the underlying desires of almost every student with a disability. A key desire is to be judged by one's performance and academic achievement and not by one's disability. Another is to make their own decisions on what challenges to undertake and play a major role in selecting the approaches and accommodations that create equity, Students with disabilities have individual needs, just like their able-bodied classmates. Those needs depend on the specific disability. All students, however, learn best when teachers address individual needs. *Teaching Chemistry* provides information about a variety of successful classroom and laboratory accommodations for students with disabilities. In many instances, the accommodations are simple, inexpensive and require little but significant change in instructional approach or additional effort from the instructor.

1.3. It's the Right Thing to Do

Why should an instructor exert that extra effort, no matter how small? There are two compelling reasons. First, instructors should provide accommodations because it is *the right thing to do*, and *Teaching Chemistry* embraces this as its central theme. Society cannot afford to limit science careers to certain groups in the population such as people with perfect eyesight or hearing, or the strong and fleet of foot. Rarely, if ever, is great physical prowess a prerequisite for a successful career in science. That makes science, technology, engineering, and mathematics ideal career options for individuals with disabilities. Excluding people from science based on physical attributes would be a terrible waste of human talent and diversity.

A diverse scientific workforce is increasingly recognized as essential to ensure our country's competitiveness in the high-tech global marketplace. Diversity has become an axiom in some sectors of the economy, including the global biopharmaceutical industry, among others. Companies have recognized the value of including individuals with different approaches to solving problems, life experiences, and backgrounds on multidisciplinary research teams. Many research problems can be solved most effectively when approached from multiple perspectives, and scientists who have disabilities bring unique perspectives to those teams. They also bring attributes, such as persistence and creativity, finely honed by years of developing innovative ways of excelling in academic and other pursuits despite disabilities.

The success of scientists with disabilities attests to the value of being inclusive. They have been participants in the remarkable progress of science since the 20th century, particularly in chemistry. For example, Sir John W. Cornforth, the Australian organic chemist who shared the 1975 Nobel Prize in Chemistry for research on the stereochemistry of enzyme-catalyzed reactions, was deaf. The renowned American organic chemist Henry Gilman was blind for a large portion of his career. These are just a couple examples of individuals with disabilities who have made valuable scientific contributions; there are many more who have made advances in research, education, government, and industry Those interested in learning more should read *Working Chemists with Disabilities,*[6] which demonstrates in compelling fashion that science is a viable and rewarding career choice for students with disabilities.

Instructors should also bear in mind that being able-bodied can be the most fleeting of human conditions. Accidents or illnesses can bring on physical and other disabilities in an instant. In addition, the inexorable advance of time makes us all increasingly less able-bodied and more in need of accommodations to remain productive in our careers.

1.4. It's the Law

In sections on the legal protections for individuals with disabilities, *Teaching Chemistry* details a second and more pragmatic reason for accommodating students with disabilities: *It is the law*. Schools are required to provide reasonable accommodations to students with disabilities, and schools that fail to do so may be liable to formal complaints and lawsuits, with all the attendant expense, negative publicity, and potential damage to hard-won reputations. Legal action is quite rare because issues involving accommodations usually can be resolved simply and equitably when approached in a collegial fashion.

Fortunately, the basic requirements for teaching chemistry to qualified students with disabilities are simple: capable teachers, an understanding administration, and motivated students. Many accommodations for students with disabilities are likewise simple, inexpensive and require relatively little extra effort. Ideally, every institution that has a science program and a laboratory on site should take steps to craft an accommodation process before the need arises and any accommodation should be fully integrated with the course instruction. Teachers may be surprised at the extent to which accommodations made for students with disabilities are welcomed by nondisabled students and can improve the education of every member of the class and laboratory. For example, lower height lab benches for a student in a chair will be beneficial for all short students. Using electronic equipment for data collection is also advantageous for all students. Attention to individual needs can ensure that students with disabilities participate fully in laboratory and classroom learning experiences. *Teaching Chemistry* and *Accessibility in the Laboratory* describe many situations where accommodations are warranted and offer suggestions for implementation.

The ACS Committee on Professional Training (CPT) has joined CWD in stating that any disability should never exclude a qualified student from an educational activity as important as laboratory work. Given the appropriate accommodations, a student with a disability can experience and learn from all aspects of a laboratory exercise. Some students with limited mobility, restricted dexterity, or vision disabilities may need a lab assistant who will set up and perform physical manipulations of experiments under the student's direction. Withholding the appropriate accommodations essential for the student's laboratory experience can be very detrimental and potentially carry unwanted legal ramifications.

1.5. Inclusion versus Full Participation

For the reasons stated, students with disabilities should be *included* in the chemistry classroom and laboratory. Inclusion has been their overriding goal for decades. Instructors, however, should strive—to the greatest extent possible—for an objective that goes beyond inclusion. Inclusion to many individuals with disabilities now means being allowed in the classroom or lab section. Just being there is not enough. Students must be in an environment

that permits full access to the same educational experience available to their able-bodied classmates. The 21st century goal is not just inclusion but *full participation*. Here it should be clearly stated that the onus for creating an atmosphere of full participation does not fall solely on the instructor's shoulders. Full participation can best be achieved through that *magic triangle* in which the instructors, student with disabilities, and professional staff in the college DSS office or its high school counterpart all work together.

Accommodations should not be reserved only for high school students headed for a college major in science or the college student majoring in chemistry. All citizens in a modern technological society should have basic knowledge of chemistry and the rest of science, to make informed decisions and participate in local and national debates. Scientifically literate citizens are better equipped to make decisions, including those involving the funding of scientific research. Likewise, the accommodations necessary to experience chemistry in the classroom and laboratory should be extended to all students with disabilities, including those who plan to take only one chemistry course. Chemistry is the central science, and the study of chemistry is a gateway to a whole range of careers in the sciences and health professions. Non-accommodation in chemistry classes would foreclose a large range of career options to people with disabilities.

1.6. Strategies, Methods, and Resources

Teaching Chemistry provides an overview of instructional strategies, methods, and resources. It includes sections on legal rights of students with disabilities, responsibilities of their teachers and institutions, advice on obtaining needed resources, teaching strategies for the classroom and laboratory, techniques for testing and evaluation, tips on incorporating assistive technology, ideas for improving laboratory access for everyone through universal design, and much more. Chemistry education does not end at the classroom or laboratory door. *Teaching Chemistry* thus includes information on internships, which provide critical real-world work experience for students with disabilities; tips on preparing for job interviews; mentoring and advocacy advice; and other resources for helping students successfully undertake that rite of passage as they transition from school to a productive career.

This book is not intended to be comprehensive. Rather, it should serve as a primer for everyone who is involved with the education of students with disabilities at all levels at all educational institutions. *Teaching Chemistry* is a starting point for locating more in-depth information and further resources. It includes descriptions of organizations, web addresses, and other information, which will be regularly updated on the accompanying website.

1.7. Assessing the Success of Accommodations

With every strategy, approach, adaptations, etc., it is important to verify the success of any steps that were taken. This is true for all programs; if there is no attempt to assess whether a program is having its intended effect, that everyone affected by the program benefits, and that it is not cost prohibitive, then that program stands a high chance of failure. Formative as well as summative assessments would be ideal, as both "disability" and "accommodation" can be

moving targets, so periodic examinations about the accommodation will determine if some adjustment is needed.

1.8. Effect of the COVID-19 Pandemic on SWD Learning and Education

The Pew Research Center released a 2020 report on the impact of the virus and pandemic: closing primary and secondary schools across the country forced a sudden and widespread shift to online learning.[7] The sudden change also wreaked havoc among colleges and faculty members but was especially challenging for the nation's students with disabilities. Instruction and support for SWD are not, in all cases, easily transferred to the internet, and this has added unprecedented stress and frustration for both SWD and the institutions which serve them.

It may seem counterintuitive, but a Pew study, carried out before the pandemic hit, explained that a survey of Americans ages 18 and older, found that disabled Americans expressed lower levels of comfort with using technology and the internet.[8] Disabled adults are less likely than those without a disability to say that they have a high level of confidence in their ability to use the internet and other communication devices to keep up with information (39% vs. 65% of all adults). Moreover, a Pew study in 2017 indicated that disabled adults are roughly 20 percentage points less likely to subscribe to home broadband and own a traditional computer, a smartphone, or a tablet. These are facts to bear in mind as we strive for full inclusion.[8]

There have also been some significant outcomes in terms of accessibility and inclusivity necessitated by the pandemic. Flexible and remote ways of working have been widely adopted, many scientific conferences and meetings have moved online (free or at a reduced fee), and increased use of video conferencing has reduced isolation. However, challenges remain for many disabled scientists as recently highlighted by Krystal Vasquez, including inaccurate captions and inaccessible presentations.[9]

1.9. In summary

With all the resources available, there should be no one in a high school, college, or technical college that hesitates to talk about accommodations for SWD – the legal responsibilities of the ADA, the real or perceived burden placed on an instructor when a SWD enrolls in a course, what steps *can* be taken, and when specific steps *must* be taken. In today's current climate of rising awareness of racism and searching for solutions, let's remember that SWD also suffer from discrimination and action must be taken to remediate this and remove barriers to equal educational opportunities for all students. Creating a campus-wide climate of inclusion, promoting a student's sense of belonging, and validating their identities in and out of STEM classrooms will go a long way towards promoting academic justice and keep us on the road towards a STEM community of scholars and workers that is more closely representative of the highly diverse nature of our nation.

1.10. References

1. Colorado Department of Education. *Twice-Exceptional Students Gifted Students with Disabilities, Level 1: An Introductory Resource Book*, 4th ed.; Chelin, D., Ed.; Muddy Paws Publishing, LLC, 2017.

2. Hussar, B.; Zhang, J.; Hein, S.; Wang, K.; Roberts, A.; Cui, J.; Smith, M.; Bullock Mann, F.; Barmer, A.; Dilig, R. *The Condition of Education 2020 (NCES 2020-144)*. U.S. Department of Education, National Center for Education Statistics: Washington, DC, 2020. https://nces.ed.gov/pubs2020/2020144.pdf (accessed 2023-07-21)

3. The percentages are of the total number of U.S. undergraduate students. Source: *Digest of Education Statistics, 2017 (2018-070).* U.S. Department of Education, National Center for Education Statistics: Washington, DC, 2019.

4. *U.S. Bureau of Labor Statistics, U.S. Department of Labor*, February 26, 2020; USDL-20-0339.

5. *Accessibility in the Laboratory*; Sweet, E., Gower, W.S., Hetzel, C.E., Eds.; ACS Symposium Series 1272, sponsored by the ACS Division of Chemical Health and Safety; American Chemical Society: Washington, DC, 2018. DOI: 10.1021/bk-2018-1272 (accessed 2023-07-21)

6. Woods, M.; Blumenkopf, T.A. *Working chemists with disabilities: expanding opportunities in science*; American Chemical Society Committee on Chemists with Disabilities; American Chemical Society: Washington, DC, 1996.

7. Schaeffer, K. As schools shift to online learning amid pandemic, here's what we know about disabled students in the U.S. *Pew Research Center*, April 23, 2020. https://www.pewresearch.org/short-reads/2020/04/23/as-schools-shift-to-online-learning-amid-pandemic-heres-what-we-know-about-disabled-students-in-the-u-s/ (accessed 2023-07-21)

8. Perrin, A.; Atske, S. Americans with disabilities less likely than those without to own some digital devices. *Pew Research Center,* September 10, 2021. https://www.pewresearch.org/short-reads/2021/09/10/americans-with-disabilities-less-likely-than-those-without-to-own-some-digital-devices/ (accessed 2023-07-21)

9. Vasquez, K. Virtual Conferences Aren't as Accessible as You Might Think. *Scientific American*, February 18,2021. https://www.scientificamerican.com/article/virtual-conferences-arent-as-accessible-as-you-might-think/ (accessed 2023-07-21)

Chapter 2. Disability Laws and Services

Theresa L. Windus*,[1] and Melissa Postlewaite[2]

[1]Department of Chemistry, Iowa State University and Ames National Laboratory, 125 Spedding Hall, Ames, IA 50014
[2]Chair of American Institute of Chemical Engineers Disability Outreach and Inclusion Committee,129 Hampshire Drive, Deptford, NJ 08096
***Email: twindus@iastate.edu**

Chapter 2 Contents

2.1 **Introduction**
2.2 Rehabilitation Act of 1973
2.3 Individuals with Disabilities Education Act (IDEA)
2.4 Americans with Disabilities Act (ADA) of 1990
2.5 Institutional Responsibilities
2.6 Faculty Responsibilities in Higher Education
2.7 Student and Faculty Responsibilities Working with the DSS Office in Higher Education
2.8 Disability Harassment
2.9 References

2.1 Introduction

Many individuals with disabilities have built successful science careers in industry, education, government, and other settings.[1] Nevertheless, young people with disabilities traditionally have not enjoyed full access to the education needed for careers of their choice. The problem stems in part from a lack of physical access to school buildings and facilities. In addition, many students with disabilities had not even been exposed to the sciences, including chemistry and the many fields that involve chemistry, until relatively recently.[2,3] Society's expectations of persons with disabilities were much lower only a generation or two ago. Some parents and educators may have lingering misconceptions about the abilities of people with disabilities to compete and achieve in the sciences. Individuals involved in the education of students with disabilities should strive to educate colleagues and others, helping to remove attitudinal barriers.

About 6% of the students in grades K–12 have an identifiable disability.[4,5] College chemistry faculty can increasingly expect to teach more students with disabilities than ever before. Some will be non-chemistry majors taking a single introductory course. An increasing number of students seeking associate, baccalaureate, and advanced degrees in chemistry and related fields will require a more extensive study of chemistry. More students with disabilities also are

participating in high school chemistry, partly because of laws that require education of most individuals in regular classroom settings.

The U.S. Congress has established a comprehensive legal framework for preventing discrimination against individuals with disabilities and ensuring their full participation in society. Several of these laws apply to educational institutions and make the full range of educational opportunities accessible to persons with disabilities. They include the Rehabilitation Act of 1973;[6] the Education for All Handicapped Children Act of 1975 (now called the Individuals with Disabilities Education Act, or IDEA);[7] the 1997 and later amendments to IDEA;[7] and the Americans with Disabilities Act of 1990 (ADA).[8] These laws define the responsibilities of educators to students with disabilities and the overall process by which students are ensured accommodation and access to educational resources. Grades K–12 are addressed primarily in the Rehabilitation Act of 1973 and IDEA. College-level education is addressed mainly in the Rehabilitation Act of 1973 and the ADA. The provisions of these laws, like those of any other, are subject to change. For instance, court decisions may significantly alter the rights and responsibilities of both students and educational institutions. Legislative bodies may amend their original legislation. Government agencies may issue new regulations that change the specific ways in which laws must be implemented. The focus of this document is primarily for high school and higher-education students, although there is some information for primary education as well.

One important part of the law is the definition of disability. A disability is a physical or mental impairment that substantially limits an individual in performing one or more "major life activities." These include everyday activities such as caring for oneself, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, and working. Legally, a person is disabled if he or she has a disability, has a record of the disability, or is regarded as having the disability. Under the ADA and Section 504 of the Rehabilitation Act of 1973, individuals with disabilities are guaranteed certain protections and rights for equal access to programs and services. In addition, the U.S. Office of Personnel Management has set Affirmative Action guidelines for federal positions for 12 targeted disabilities.[9,10]

While less known than other types of harassment, students with disabilities are also safeguarded from harassment under Section 504 and Title II.[11-13] The last section of this chapter discusses some of the important points of protection from harassment.

2.2 Rehabilitation Act of 1973

Section 504 of the Rehabilitation Act of 1973 applies to institutions, including public and private schools that receive federal funds. It covers students with disabilities in postsecondary education and K–12 students who are not covered under IDEA (described in the next section). A single excerpt from this equal rights law for individuals with disabilities makes its intent clear:

> *No otherwise qualified handicapped individual … shall, solely by reason of his handicap, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance.*

Under the law, schools cannot discriminate in the recruitment, admission, or treatment of students with documented disabilities; limit the number of students with disabilities admitted; make pre-admission inquiries as to whether an applicant is disabled; or use admissions tests or criteria that inadequately measure the academic qualifications of students with disabilities because special provisions were not made. Among other provisions, the law prohibits schools from excluding a qualified student with a disability from any course of study.

Students with disabilities may request modifications, accommodations, or auxiliary aids to participate in and benefit from all postsecondary educational programs and activities. To the greatest extent possible, institutions must make those changes to ensure that students with disabilities have access to an education. “Access” includes both physical facilities and programs. Schools must make accommodations to remove both physical and programmatic barriers to students with disabilities. Assistive technology in the classroom, for instance, may be needed to ensure that students who are blind or deaf can learn from lectures on par with their nondisabled peers. Ramps, automatic doors, elevators, or other architectural modifications may be needed to ensure wheelchair users have access to buildings and upper-floor classrooms. Modifications alone are not sufficient. Accommodations must be properly maintained and kept in good working order.

2.3 Individuals with Disabilities Education Act (IDEA)

IDEA provides federal assistance to states for educational services for individuals with disabilities up to age 22 or high school graduation. The law guarantees a free, appropriate public education (“FAPE”) to all students with disabilities. IDEA gives local schools several responsibilities. First, they must determine whether the student has a disability. Second, they must determine the student’s educational needs. Third, they must develop an Individualized Education Program (IEP) for students with disabilities in grades K-12. Note that IEPs are not required or generally used in post-secondary education. IDEA through a series of reauthorizations also requires that children with disabilities be educated in the least restrictive environment (“LRE”). In general, this provision provides that students with disabilities will be educated with their nondisabled peers and precludes assigning students with disabilities to “special education” classes, separate schooling, or other removal from the regular education environment. Such exclusion can occur only when the nature or severity of the disability is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily.[8,14,15] It is important to note that this does not preclude parents and students from choosing specialized schooling choices. For example, many students that attend a School for the Deaf do so by choice as a Cultural Linguistic option. Students can gather with peers and instructors that share their language and culture, and this allows them to have a much more immersive education experience. Many students that attend Schools for the Blind currently are students with multiple disabilities, and once again this is a school of choice. Generally, families will choose to send a student to a School for the Blind when they determine that the student would benefit from a fully visually accessible environment.

There is ample evidence to indicate that laboratory experiences enhance science learning. Therefore, laboratory participation is essential in providing students with disabilities an equal opportunity to learn. Science facilities must be accessible and usable for individuals with disabilities in daily use and for evaluating students’ performance. Schools may be required to

acquire or modify equipment or devices, make appropriate adjustments or modifications of examinations, provide qualified readers or interpreters, and modify teaching materials and classroom policies for students with disabilities. As covered in more depth in the later chapters, accommodations may include accessible classrooms and laboratories, special testing situations, assistants or interpreters, special adaptive equipment, multimodal teaching strategies, and full access to educational opportunities for all students with disabilities.

2.3.1 What is an IEP?

An Individualized Education Program (IEP) is a written plan for facilitating the student's education in K–12. Many schools used IEPs in the past; IDEA-97 made them mandatory. IEPs are a central part of IDEA's goal of improving the education of children with disabilities who are younger than 22. IDEA also requires that students with disabilities generally be educated with their nondisabled peers in regular classrooms.[16] IDEA mandates establishment of an IEP team for students who need tailored education and related services. In general, an IEP is required for all children in special education. An IEP, however, is not always required for students who can fully participate in a normal classroom setting without additional accommodations. In this case, a student may qualify for a 504 plan (see below). An IEP consists of a written statement for each child, which is developed by the IEP team and reviewed and revised at least once a year.

The IEP must include:[17]

- the child's present level of educational performance;
- annual measurable goals and objectives;
- recommended special education and related services;
- a description of the least restrictive environment and the plan for participation in the regular curriculum with nondisabled peers; dates, frequency, location, and duration of services;
- assessment methods;
- a transition plan by age 16; and
- process monitors and parent reporting procedures.

An IEP team should include:[17]

- the parents of the child with a disability;
- at least one regular-education teacher (if the child is, or may be, participating in regular education);
- at least one special education teacher or, if appropriate, at least one special education provider for the child;

- a representative of the local education agency who meets certain specified requirements, such as the ability to represent the agency and local school authority to justify the team recommendations and maintain compliance with the law;

- an individual who can interpret the instructional implications of evaluation results;

- at the discretion of the parents or agency, other individuals who have knowledge or special expertise regarding the child, including related services personnel (such as an itinerant specialist); and whenever appropriate, the student, especially at the secondary level or transition meetings.

Most state and local agencies make the special educator on the IEP team responsible for implementing the IEP. The regular educator is required to assume an active role in educating students with special needs. Legislation lacks specific recommendations on how schools should provide the teacher in-service training and time necessary to accomplish successful collaboration in the regular classroom.[14,18] The regular education teacher's role in these meetings is clearly required and defined. He or she is a member of the IEP team and must, to the extent appropriate, participate in the development of the IEP for the child. These responsibilities include determining appropriate positive behavioral intervention strategies and supplemental aids and services, program modifications, and support for school personnel.[8]

In addition to or instead of an IEP, some students may have a "504 plan," which describes accommodations that are not of an instructional nature.[19] For example, a student with mobility impairment may be allowed to leave all classes 2 minutes early to avoid congested hallways and arrive at the next class on time. A student with ADHD may have a plan that describes help with organizational skills that will ensure that homework will be brought to class. When a student graduates from high school, IDEA requires that the school provide the child with a summary of the child's academic achievement and functional performance, and recommendations on how to assist the child in meeting his or her postsecondary goals. This is typically discussed at a transition meeting arranged by the high school.

2.4 Americans with Disabilities Act (ADA) of 1990

Title II of the ADA of 1990, which became effective in 1992, covers state and local government programs and activities, and Title III of the ADA addresses public accommodations. The Public Accommodations section extended accessibility requirements to private schools (as well as most public meeting places, libraries, restaurants, museums, and public mass transportation systems). The law also provided private schools with tax incentives for reducing architectural barriers and making facilities fully accessible to students with disabilities.

The U.S. Department of Education's Office of Civil Rights (OCR)[20] and the ADA[8] recognize that students with disabilities may need to seek outside redress when reasonable accommodations are not provided. Students can file complaints with the OCR.[21] They can also file lawsuits under the ADA in order to obtain injunctive relief in the form of remediation of a barrier to access and they may also recover attorneys' fees. As noted elsewhere in this eBook, most disagreements over accommodations can be resolved when the student, teacher, and

Disability Services for Students (DSS) office work together in a collegial manner. Legal action is rarely needed when this spirit of cooperation exists. However, the state or local entity or the public accommodation bears the burden of ensuring that there are no barriers to access its goods or services for disabled individuals without a request for accommodation.

Some states recognize the obligation to make all hardware and software used in higher education accessible for students with disabilities. Consult your state guidelines for implementation of Section 508 and the ADA.[22]

Among the sources for keeping current with the changing legal and regulatory environment is the U.S. Department of Justice Guide to Disability Rights Laws website.[23] It includes downloadable technical assistance manuals and a great deal of other information. Regular updates of the web version of this eBook will be another useful source.

2.5 Institutional Responsibilities

Institutions have distinct responsibilities under the ADA and Section 504. Institutions must appoint an ADA/504 compliance officer/coordinator; self-evaluate their campuses for physical and program accessibility; develop a transition plan for accessibility whenever necessary; and provide assurance that they comply with the laws and offer access to all programmatic areas (e.g., academic, administrative, business, employment), including institutionally supported events and activities. In addition, they must institute methods, policies, procedures, services, and programs to ensure provision of appropriate accommodations for students, faculty, and staff with disabilities; provide training and resources for faculty and staff regarding provisions; and establish grievance procedures.

Faculty and staff have a responsibility to ensure that each course is accessible. They must work with their institutions to ensure nondiscrimination by creating equal access for qualified students with disabilities through the provision of reasonable and appropriate accommodations. Accessibility is essential and should be in the forefront of course and technological planning.

The most important goal for the student with a disability is to participate in the course as fully as possible. In chemistry, that means having an educational experience equal to that of other students. Advances in assistive technologies, such as automated lab controls and virtual laboratories, continue to expand educational and professional opportunities for individuals with disabilities. The student's responsibility is to advocate and request accommodations to capitalize on their own capabilities, using accommodations to maximize the learning experience. The educator's responsibility is to teach students effectively and provide appropriate accommodations in response to a student's request. Ultimately, the responsibility for learning class material rests with the student. The purpose of accommodations is to provide access for each student, regardless of their disability.

2.5.1 Disability Services for Students in Postsecondary Institutions

Postsecondary institutions have staff who are knowledgeable about these responsibilities and laws and assure that the institution meets its obligations to students with disabilities. They can

be valuable resources for students with disabilities and their instructors. Some campuses have a specific disability compliance support program, which may be called Disability Support Services for Students, Disabled Student Services, Disability Resource Center, or some similar title. It may be part of another office, such as Student Affairs. All campuses must at least have an ADA compliance officer or coordinator. For simplicity, this eBook will refer to this resource as the Disability Services for Students (DSS) office. A DSS office has overall responsibility to verify student eligibility for disability accommodations; work with students in recommending accommodations; and provide certain accommodations, such as interpreters for students who are deaf and recorded textbooks for students who are blind. The DSS office provides students with a uniform way to request disability services and accommodations without divulging personal medical information to faculty. Students requesting accommodations, however, must document the existence of a qualifying disability (see disability definition above) to the DSS office. The documentation establishes eligibility for accommodations and services. It is important to note that postsecondary institutions do not use IEPs.

The most successful outcomes usually occur with an approach that has been termed the “magic triangle.” It involves faculty working closely with the student and the DSS office. This interaction usually results in selection of the most appropriate accommodations for each individual student. In each instance, there may be several effective alternatives for reasonable and appropriate accommodations. Once a student initiates a request, all three parties can play an important role in providing a student an appropriate accommodation.

2.5.2 What is the DSS Office?

The DSS staff assists students and faculty in the disability accommodation process. It ensures that accommodation recommendations are effective for the student while being reasonable for the institution and faculty. Some DSS offices may have detailed suggestion sheets available for accommodations and teaching strategies for students with various disabilities. An accommodation should not compromise an institution’s academic standards or the content of a specific course. It is important to remember that the laws that protect the rights of individuals with disabilities also protect the standards of the institutions being attended. Having a disability does not preclude a student from meeting the essential course requirements or from following the established policies and procedures of the institution.

Many students with disabilities receive financial assistance from their state Department of Vocational Rehabilitation Services (DVR). DSS counselors often work with students and DVR staff to arrange accommodations and other support services that may be funded through DVR. The typical DSS office does not directly provide all support services for students with disabilities. The DSS staff, however, is generally very knowledgeable about campus, community, and national support programs. Counselors usually can assist students in obtaining almost any needed service from these and other sources.

Here are a few examples of the types of services that DSS offices can provide, or referrals for these services, for students with disabilities:

- academic and career advising;

- campus and community referrals;
- individualized recommendations regarding appropriate accommodations;
- registration and advisement referrals, early (priority) preregistration;
- on-campus parking privileges;
- adaptive technology centers;
- audio books and e-texts, in coordination with DSS offices and services such as the National Library for the Blind and Print Disabled;[24]
- in-class note-taking programs;
- nonstandard academic testing accommodations;
- specialized equipment for specific disabilities, such as assistive listening devices;
- interpreting, including American Sign Language or oral interpreting services;
- real-time captioning and C-print;
- access to a Video Relay Service;
- educational materials and lab equipment adaptations;
- alternative print formats, such as Braille, large print, computer-based files, and taped text;
- tactile visual aids, such as raised line charts and graphs;[25]
- on-campus accessible transportation; and
- information dissemination to teaching and lab assistants: Often the faculty member is notified about the student and his or her accommodations but neglects to inform the lab and teaching assistants or other faculty and staff who will interact with the student.

Both faculty and students should develop a rapport with DSS staff and use the DSS office as a resource for answering questions, clarifying issues, and assisting with accommodations.

2.6 Faculty Responsibilities in Higher Education

The phrase “Teachers must provide accommodations…" can cause concern among faculty, especially those teaching their first students with disabilities. For example, teachers may mistakenly think that they personally must obtain assistive devices and provide them for the student. Instructors have the responsibility for providing some accommodations that make course content accessible to the student, such as advance copies of written instructional

material that can be converted into alternative formats. In most instances, however, "provide" means that the instructor must permit or make possible use of assistive devices and other accommodations provided by the student, the DSS office, or an outside agency.

In addition, it is very important for faculty to clearly define the essential requirements for each course and make the information available to students and the DSS office in advance. What textbooks will be used? What supplemental reading will be assigned to the class? What are the dates for tests? Providing this information ahead of time will give the DSS staff adequate time to work on accommodations.

Faculty should meet requested deadlines for getting course reading materials to the DSS office, to ensure that personnel have adequate time to convert those materials into alternative formats whenever necessary. It may take weeks, for instance, for DSS staff to obtain recorded or Braille versions of course reading materials.

The DSS office makes recommendations for accommodations on the basis of the disability documentation provided by the student. The student then conveys the recommendations in a letter to the instructor. Teachers should know that students usually self-identify as having disabilities because they will require an accommodation; however, students are not required to disclose the nature of the disability to the teacher – only the required accommodations. To the extent a student volunteers information about their disability, listen carefully to what they say. Avoid asking intrusive or follow-up questions about the information a student may have provided about their disability. Rather, focus your discussion and questions on the accommodations requested and respect the student's right to privacy and confidentiality.

Priority course preregistration is an essential accommodation for some students with disabilities. Early registration ensures that instructional materials and any necessary assistive technology are available for the first day of class. In addition, early registration gives students with disabilities access to a course schedule that provides ample time for traveling to the next class or taking a break between classes. It is also important to allow adequate time for course planning before the semester begins. In addition, the instructor should prepare for possibilities like the evacuation of students with mobility and vision disabilities from the building during emergencies. DSS services, teachers, and counselors can help by informing the instructor in advance when students with disabilities will be in a class.

In addition, some students may have difficulty approaching an instructor or DSS due to issues such as anxiety, paranoia, autism, or cultural stigma (see Chapter 3 for more information). Creating an environment of open communication is important.

2.6.1 DSS Assistance with Accommodations in Higher Education

DSS offices have resources to assist the teacher in providing many accommodations, such as converting written course materials into Braille, enlarged print, recordings, or digital files. However, it is essential that teachers give DSS personnel adequate lead time. In some cases, alternative formatting may take 10–16 weeks. Interpreters should also be given copies of all printed materials in advance. Depending on the approved accommodations, audiovisuals, such as slides and overheads, should be copied and given to students with hearing impairments prior

to the class. If course materials include video, it is important to ascertain whether the videos have caption-based text and whether the appropriate decoding equipment is available. The wide use of word processing programs and other software has greatly simplified this process for teachers, who routinely prepare classroom and lab materials in computer files. With handouts and overheads in digital format, teachers already are prepared to respond to accommodation requests for alternative formatting with an e-mail attachment to the DSS office. DSS personnel can assist with this process as well.

Although some disabilities are apparent, such as using a wheelchair or a service dog, many are not readily visible. Some students may be reluctant to disclose disabilities or ask for accommodations. The most effective instructors provide all students with a list of resources for the course, including the availability of services through the DSS office. Many instructors, for example, include on each course syllabus wording to the effect: "If you think you may need accommodation due to a disability, please contact the campus Disability Services Office as soon as possible, or the instructor."

Teachers sometimes may suspect that a student's poor academic performance is due to an invisible disability. In such cases, the teacher may discuss the student's academic performance with the student in private, as would be done with any other student. A student might disclose a disability-related difficulty at this time or describe difficulties that suggest a possible disability. In such cases, college teachers should refer the student to the DSS office for information about accommodations or procedures to verify the existence of a disability. Teachers should not imply or suggest to a student that they may have a disability or need an accommodation. If you have concerns that a student may have difficulties stemming from a possible disability, confer with your DSS office. Postsecondary teachers should adhere to all guidance provided by their institutions. Likewise, K–12 teachers should also follow their school's established procedures for conferencing with parents and counselors.

It is imperative that students in high school or college are involved in the process of arranging their accommodations. Unfortunately, some teachers may still bypass the student and the DSS office and consult only other teachers or advisers. This can lead to frustrating situations. One practicing research chemist who has a disability recalled his experiences with such situations: "I was constantly frustrated in my attempts to arrange pre-semester conferences by teachers who said that they had 'already spoken to so-and-so and everything was arranged.' This left me completely in the dark about what had been arranged and unable to express my views on what needed to be arranged." The best outcomes usually occur when faculty work closely with the student with a disability and with the DSS office.

2.7 Student and Faculty Responsibilities Working with the DSS Office in Higher Education

Students and faculty have distinct responsibilities in working with the DSS office. Students with disabilities and faculty must allow adequate time for DSS offices to process requests for accommodations. Teachers have a responsibility to ensure that appropriate alternative formats of in-class materials are available to qualified students with disabilities at the same time as their peers. These include reading lists, the course syllabus, handouts, overheads, and videos. Faculty themselves need not convert written material into an alternative format.

But teachers must provide written course materials (including titles of textbooks) to the student or the DSS office. Typically, this information should be provided by the end of each preregistration period.

2.7.1 Student Responsibilities

- Students with disabilities who seek accommodations should identify themselves as needing accommodations.
- Students with disabilities should register with the DSS office to have their requests for disability accommodations verified.
- If possible, students with disabilities should preregister at the earliest opportunity to be sure their class schedule meets logistic requirements, such as allowing enough time to travel or have breaks between classes, to schedule interpreters or laboratory assistants, or to ensure that a classroom for a specific section has appropriate functionality to assist in accommodations.
- Students with disabilities should provide requested documentation of their disability.
- Students with disabilities should advocate for themselves and participate in developing accommodations.

2.7.2 Faculty Responsibilities

- Refer students to the DSS office when appropriate. Confirm students are registered with the DSS office. Students requesting accommodations who are not already working with the DSS office must be informed about and referred directly to the DSS office to establish their eligibility for disability accommodations.
- Understand student self-disclosure. Students requesting accommodations are only required to provide a letter from their DSS program coordinator stating that they have a documented disability on file at the DSS office. Students are not required to divulge the nature of their disabilities or provide faculty and staff with copies of their disability documentation. The student is not obligated to share medical information with the teacher or otherwise additionally justify the DSS-approved request for accommodation.
- Honor student confidentiality. Disability/accommodations information is confidential and should not be mentioned in front of classmates or other individuals, without the explicit permission of the student. That includes other students whom a professor might ask to serve as a note taker or a lab partner for the student who has requested such accommodations. When requesting accommodations, students expect that confidentiality will be maintained.

- Apply consistent standards. Students' requests to the DSS office for accommodations after the fact (such as retaking an exam with accommodations after having failed the exam) should be handled in consultation with the DSS office and generally with the same standards applied to all students.

- Define course requirements. Clearly define the essential elements of each course, including learning objectives, reading lists, written assignments, and projects. If the essential course elements are not clearly defined, inconsistencies in standards may occur that could cause misunderstandings or even administrative complaints and litigation.

- One responsibility of faculty cannot be overemphasized: Ensure that DSS personnel have adequate time to complete arrangements for alternative formatting and other required accommodations. In many instances, DSS offices do not perform the actual alternative formatting themselves. Instead, they hire contractors to perform these services, a process that takes time. For example, CART providers and other aids require copies of the handouts and slides well BEFORE the lessons, so words can be added to CART dictionaries.

2.8 Disability Harassment

Many institutions provide training and enforcement and implement safeguards for sexual harassment. Employees are often trained in identifying sexual harassment and its consequences. Unfortunately, the same measures are seldom taken for disability harassment.

Disability harassment is unwelcome conduct based on a person’s disability or perceived disability. Harassers can be anyone: students, staff, or even someone visiting. Just like sexual harassment, disability harassment is an illegal form of discrimination. Thus, it is the institution's responsibility to take a stance against disability harassment.

Disability harassment is a form of discrimination prohibited by Section 504 and Title II.[11-13] Disability harassment is legally actionable when it is so severe, pervasive, and objectively offensive that it bars the victim access to an educational opportunity or benefit. Disability harassment may also violate state and local laws, and even be considered child abuse in cases with minors in some rare instances. Some state and local laws may impose obligations on educational institutions to contact or coordinate with state or local agencies or police with respect to disability harassment. Institutions should make sure they are aware of their state and local laws and follow them.

Disability harassment should be dealt with in a quick and efficient manner. “When disability harassment is not dealt with quickly and effectively, personnel may be subjecting their school districts to legal risks.[26] Educational institution officials need to develop policy and procedures for disability harassment. School district officials must ensure that administrators, principals, teachers, staff, students, and the larger institution community have up-to-date training, so they understand disability harassment and their responsibilities to combat it. The six different types of major disability harassment and their behaviors are:[27]

- *Pigeonhole:* Patronize, gawk, spurn, or scorn;
- *Abandon:* Ignore, neglect, shun, or ostracize;
- *Manipulate:* Trick, feign, entrap, goad, or slander;
- *Belittle:* Tease, needle, name call, gossip, mimic, ridicule, or mock;
- *Scare:* Taunt, prey, threaten, or torment;
- *Violate*: Trip, steal, shove, or hit.

It is not enough for school administrators to just adopt a disability harassment policy or a bullying policy. For such a program to be effective it needs to be research based, published, communicated, implemented, and enforced with fidelity. Regardless of a school's bullying policy, responsible parties can turn a blind eye. Enactments endorsed only on paper do nothing. The life of a rule is in its enforcement.

When an educational institution knows or reasonably should know of possible liability harassment, it must take immediate and appropriate steps to investigate or otherwise determine what occurred. If an investigation reveals that the harassment created a hostile environment, the educational institution must take prompt and effective steps reasonably calculated to end the harassment, eliminate the hostile environment, prevent its recurrence, and, as appropriate, remedy its effects.

Note that school districts must also assess the effect of bullying and harassment on a student with a disability even if it was not disability-based harassment and even if it did not create a hostile environment.

The U.S. Department of Education's Office for Civil Rights (OCR) investigates and resolves allegations that educational institutions that are recipients of federal funds or that are public entities have failed to protect students from harassment based on disability. Where OCR identifies concerns or violations, educational institutions often resolve them with agreements requiring educational institutions to adopt effective anti-harassment policies and procedures, train staff and students, address the incidents in question, and take other steps to restore a nondiscriminatory environment. Some state agencies may also provide students with a process to pursue a complaint alleging discrimination based on disability.

2.9 References

1. Stem, V. W.; Summers, L. *AAAS Resource Directory of Scientists and Engineers with Disabilities*, 3rd ed.; American Association for the Advancement of Science: Washington, DC, 1995; ISBN 0-87168-576-0.

2. Bryan, J. Laboratories for All: Children with Disabilities Are Out in the Cold When It Comes to Doing Science Experiments. A New Generation of Gadgets Is Now Bringing Them into

the School Laboratory. *The New Scientist*, June 9, 1990. https://www.newscientist.com/article/mg12617204-300/ (accessed 2023-07-21)

3. Lang, H. G.; Propp, G. Science Education for Hearing Impaired Students: State of the Art. *Am. Ann. Deaf* **1982**, *127* (7), 860-869. DOI: 10.1353/aad.2012.1174 (accessed 2023-07-21)

4. National Science Foundation. *Women, Minorities, and Persons with Disabilities in Science and Engineering* (NSF 21-321); NCSES: Arlington, VA, 2021. https://ncses.nsf.gov/pubs/nsf21321 (accessed 2023-07-21)

5. National Center for Science and Engineering Statistics. *Data Tables*. https://ncses.nsf.gov/pubs/nsf19304/data (accessed 2023-07-21)

6. U.S. Equal Employment Opportunity Commission. *The Rehabilitation Act of 1973*. https://www.eeoc.gov/statutes/rehabilitation-act-1973 (accessed 2023-07-21)

7. U.S. Department of Education. *Individuals with Disabilities Education Act (IDEA)*. https://sites.ed.gov/idea/ (accessed 2023-07-21)

8. United States Department of Justice, Civil Rights Division. *Introduction to the Americans with Disabilities Act (ADA)*. https://www.ada.gov/topics/intro-to-ada/ (accessed 2023-07-21)

9. U.S. Office of Personnel Management. *Affirmative Action Plan for the Recruitment, Hiring, Advancement, and Retention of Persons with Disabilities*, 2017. https://www.opm.gov/about-us/our-people-organization/support-functions/equal-employment-opportunity/affirmative-action-plan-for-people-with-disabilities.pdf (accessed 2023-07-21)

10. U.S. Office of Personnel Management. *Self-identification of Disability*, 2016. https://www.opm.gov/forms/pdf_fill/sf256.pdf (accessed 2023-07-21)

11. U.S. Department of Education, Office of Civil Rights. *Protecting Students with Disabilities*. https://www2.ed.gov/about/offices/list/ocr/504faq.html (accessed 2023-07-21)

12. United States Department of Justice, Civil Rights Division, ADA.gov. *State and Local Governments (Title II)*. https://www.ada.gov/topics/title-ii/ (accessed 2023-07-21)

13. Code of Federal Regulations. *Part 35 – Nondiscrimination on the Basis of Disability in State and Local Government Services*. https://www.ecfr.gov/current/title-28/chapter-I/part-35 (accessed 2023-07-21)

14. Lipsky, D.K.; Gartner, A. Taking Inclusion into the Future. *Educ. Leadership* **1998**, 56 (2), 78-82.

15. U.S. Department of Education, Office of Special Education and Rehabilitation Services. To Assure the Free Appropriate Public Education of All Children with Disabilities; Individuals with Disabilities Education Act Section 618: 44th Annual Report to Congress on the Implementation of the Individuals with Disabilities Education Act; Washington, DC, 2021; https://www2.ed.gov/about/reports/annual/osep/index.html (accessed 2023-07-21)

16. U.S. Department of Education, IDEA. *Section 1412 (a) (5)*. https://sites.ed.gov/idea/statute-chapter-33/subchapter-ii/1412/a/5 (accessed 2023-07-21)

17. U.S. Department of Education, IDEA. *Section 1414 (d)*. https://sites.ed.gov/idea/statute-chapter-33/subchapter-ii/1414/d (accessed 2023-07-21)

18. Crockett, J. B.; Kauffman, J. M. Taking inclusion back to its roots. *Educ. Leadership* **1998**, *56* (2), 74-77.

19. U.S. Department of Education, Office for Civil Rights. *Protecting Students with Disabilities*. https://www2.ed.gov/about/offices/list/ocr/504faq.html#interrelationship (accessed 2023-07-21)

20. U.S. Department of Education, Office for Civil Rights. https://www2.ed.gov/about/offices/list/ocr/index.html (accessed 2023-07-21)

21. U.S. Department of Education. Office for Civil Rights. *How to File a Discrimination Complaint with the Office for Civil Rights*. https://www2.ed.gov/about/offices/list/ocr/docs/howto.html?src=rt (accessed 2023-07-21)

22. *General Services Administration, Policy & Management, State Policy*. https://www.section508.gov/manage/laws-and-policies/state/ (accessed 2023-07-21)

23. *Guide to Disability Rights Laws.* U.S. Department of Justice, Civil Rights Division. https://www.ada.gov/resources/disability-rights-guide/ (accessed 2023-07-21)

24. *Library of Congress, National Library Service for the Blind and Print Disabled*. https://www.loc.gov/nls/ (accessed 2023-07-21)

25. Edman, P. *Tactile Graphics*; American Foundation for the Blind: New York, 1992.

26. Herbert, J. T.; Hong, B.S.S.; Welsh, W. A.; Kurz, C. A.; Atkinson, H. Persistence and Graduation of College Students Seeking Disability Support Services. *J. Rehabil.* **2014**, *80*, 22-32.

27. Holzbauer, J.J.; Conrad, C.F. A Typology of Disability Harassment in Secondary Schools. *Career Dev. Exceptional Individ.* **2010**, *33*(3), 143-154

Chapter 3: An Overview of Accommodations

Pedro Flores Gallardo[1] and Melissa Postlewaite*,[2]

[1]Matrix Medical Network, Employee Health & Safety, 9201 E Mountain View Rd Suite 220, Scottsdale, AZ 85258
[2]Chair of American Institute of Chemical Engineers Disability Outreach and Inclusion Committee,129 Hampshire Drive, Deptford, NJ 08096
***Email: MelissaPostlewaite@gmail.com**

Chapter 3 Contents

3.1 Introduction
3.2 Equity
3.3 Disability Support Services
3.4 At the Beginning of the Semester
3.5 Considerations during the Semester
3.6 Taking Notes
3.7 Testing and Evaluation
3.8 Past Accommodations as a Guide
3.9 In the Laboratory
3.10 References

3.1 Introduction

Academic institutions are required to provide high-quality instruction to all students, and students with disabilities are expected to and deserve to participate fully in the general education in the classroom. However, these students experience challenges or barriers that can interfere with their ability to access and demonstrate learning, and it is the responsibility of the institution to make any necessary accommodations or adjustments.

Some of the general considerations for teaching students with a disability that will be discussed in this chapter and in later chapters for specific types of disability can be associated with the following questions:

- How is information being delivered to the student? (e.g., text, lecture, videos, discussion, laboratory, size of the class)
- How is the student required to respond? (e.g., writing, speech, individual or group work and/or response)
- What are some of the environmental factors that are present in the classroom and in the building itself? (e.g., noise, lighting, seating, physical layout, building accessibility)

- What is the timing of the instruction? (e.g., the time of the day, length of the class period, frequency of the class meetings)

The accommodations and adaptations that are required for a student will depend on the student's individual needs as well as the answers to these questions. It is very possible that two students with the same disability attending the same class in the same classroom will require different accommodations. There is definitely no "one size fits all" when it comes to meeting a student's needs, whether or not that student has a disability. Two important areas that need to be evaluated and addressed by the instructor, with guidance from the Disability Services for Students (DSS) personnel, are the method of instruction and the techniques used to assess how well the student has learned the necessary content.

- *Instructional accommodations* include changes to the methods and materials used for delivery of classroom and laboratory instruction. Providing instructional accommodations changes how the student will learn, not the content itself. It does not change the level of knowledge the student is expected to learn.

- *Assessment accommodations* can be made by providing changes to the format or how the assessment is administered. An example might be the replacement of a written test by an oral test. Again, the student is expected to demonstrate the same knowledge of the material as would be expected using a possibly more traditional assessment.[1]

Designing and implementing accommodations is easier when both the instructor and student can utilize techniques and resources used successfully by that student in earlier classes. Students with disabilities in grades K–12 usually have a written plan, called an Individualized Education Program (IEP), that describes the accommodations that best address the student's learning needs at each grade level. The IEP may also provide the student with general guidance on postsecondary accommodations that might be needed. However, the IEP is not automatically shared with the college DSS; the student must initiate contact with DSS and supply this and other relevant materials (see Chapter 2 for more information about the IEP and DSS). The DSS office has the responsibility to verify the eligibility of college students with disabilities who request accommodations and will outline specific accommodations in a communication to the instructor either directly or through the student. College and university instructors can then draw on advice and other resources from the campus DSS office.

It should be noted here that many students who have an IEP in high school do not follow through and contact the college's DSS. One study indicated that the students surveyed at one institution identified five reasons why they did not utilize the college's services.[2] Their reasons included (a) identity issues, (b) desires to avoid negative social reactions, (c) insufficient knowledge, (d) perceived quality and usefulness of services, and (e) negative experiences with faculty.

Rather than focusing on accommodations specifically for students with disabilities, a universal design model that includes the learning environment of the student while making it usable and equitable for all may be more successful. Environments are designed to the greatest extent possible to be flexible, simple, and tolerable for people of all types of abilities. Universal design responses in the table below are proactive, inclusive and sustainable.

Accommodation Response:	Universal Design Response:
Access to course materials is a problem for individual students and should be addressed by the student and Disabilities Resources Center.	Access issues stem from an inaccessible curriculum and can be addressed by the instructor as part of the design of the course presentation and requirements.
Access is achieved through accommodations and retrofitting requirements.	The course is designed to the greatest extent possible to be usable by all students.
Access is retroactive.	Access is proactive.
Access is often provided in a separate location or through special treatment.	Access is inclusive.
Access must be reconsidered for each student in each course, i.e., it is consumable.	Access, as it part of the design of the course for all students, is sustainable.

Table 1: Potential Universal Design Responses vs Accommodation Responses

Chemistry departments should give serious consideration to embracing universal design in the construction of new laboratory facilities and the renovation of existing labs. Ideally, all of this should take place *before* there is a student with a disability present. These designs and teaching alterations take time to implement and need to be tested to make sure they work. If the department waits until they have a student with a disability, it may be too late for that student. Also, merely meeting the Americans with Disabilities Act (ADA) standards may fall short in helping students succeed with their course work.

A school may have sufficient, or even superior, physical facilities, but access to much needed services might be much more difficult for students to obtain. In a college environment, receiving an ADA accommodation may require high out of pocket costs for the student. A doctor's note is not sufficient to prove a disability diagnosis. Testing has to be done by a licensed specialist. Testing is not typically covered by health insurance, and the condition might need to be retested every several years even when the condition is genetic and lifelong. Getting disability services can be time consuming and costly.

3.2 Equity

It is a common misconception held by many people, not just by educational institutions, that by following the ADA regulations people with disabilities are equally included. It is also a misconception that disability accommodations "level the playing field." Disability accommodations do not always give the student equal access. They do prohibit a student from being intentionally excluded from access to an education.

In the 2015–2016 academic year, 17% of enrolled full-time undergraduates reported having a disability while 21% of undergraduate students enrolled part-time or for part of the year had a disability. Forty percent of undergraduates with a disability who started in 2011 graduated with a bachelor's degree from the same university by 2017, compared to 57% of students without disabilities.[3] Multiple reasons are given for this disparity, including but not limited to challenges navigating campus procedures, being unaware of campus resources, gaps in programs and services, financial hardships, and instructional environmental barriers. The

reality is that a student with a disability may not have equal access to a lesson as the rest of the students – even with accommodations – and that students with disabilities are less likely to be supported by their institutions than students without disabilities. For example, in a large university building, there is often only a single ramp. The building is technically accessible, but the person who uses a wheelchair can only use the accessible entrance and often has to travel further than the students that can use any entrance. This could be a problem when time is a factor in traveling between classes or when the elevator is far from the accessible entrance.

3.2.1 The Matthew Effect

The Matthew effect is a social phenomenon in which those who begin with an advantage accumulate more advantages, and those who begin with disadvantage become more disadvantaged over time. One popular adage that illustrates the Matthew effect is, “The rich get richer, and the poor get poorer”.[4]

The Matthew effect was a term created by sociologist Robert Merton in 1968, inspired by a verse in the Bible: Matthew 25:29. This verse states that “For whoever has will be given more, and they will have an abundance. Whoever does not have, even what they have will be taken from them.” The Matthew effect is also known as the Cumulative Advantage/Disadvantage Theory.

An example of the Matthew effect is the better performance and greater prospects of a hockey player when a player is born in the 1st quarter of the year (January, February, March). Due to the timing of the selection, these children are slightly older and have had (on average) more time to improve skills, maturity, strength, and other attributes. The players are sifted and sorted and evaluated with the most talented separated out and groomed for the next level. These slightly older children have an advantage when it comes to playing opportunities and better coaching. “The little difference leads to opportunity that makes that difference a bit bigger, and

that edge in turns leads to another opportunity, which makes the initially small difference bigger." Thus, there is a strong linear relationship between the month of birth and the

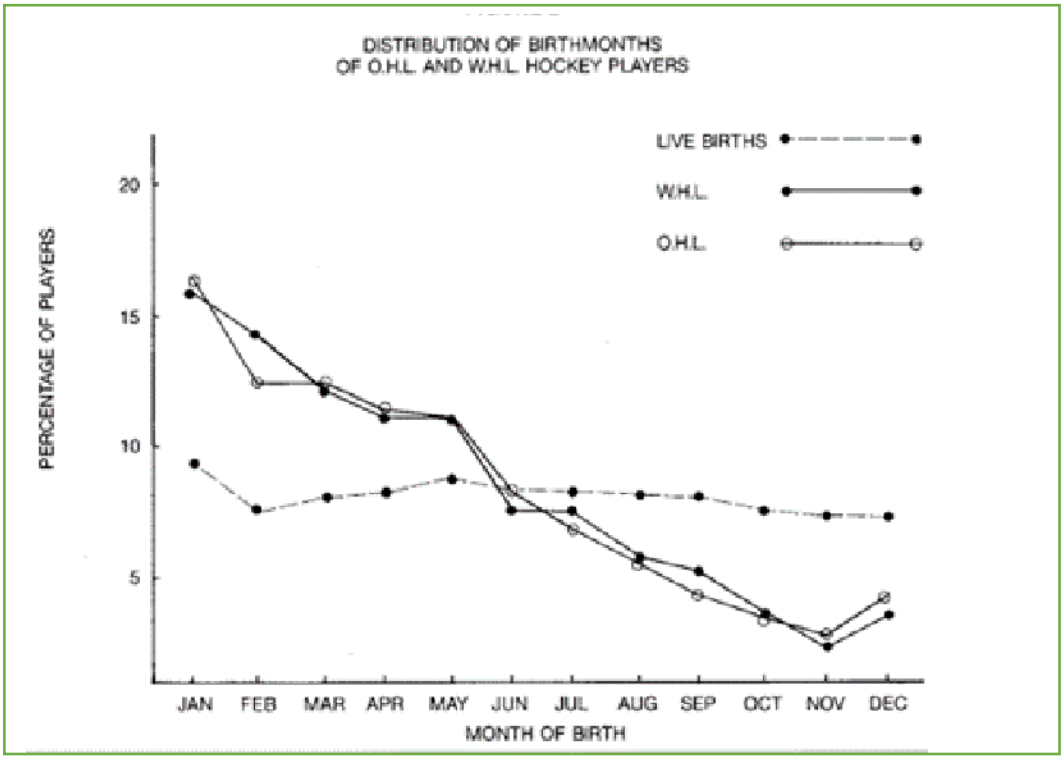

Figure 1: Distribution of birth months and percentage of players in the Western Hockey League (WHL) and the Ontario Hockey League (OHL). Reproduced from Hockey Success and Relative Age Effect published in 1985 in Canadian Association of Health, Physical Education and Recreation by R.H. Bernsley, A.H. Tompson, and P.E. Barnsley.

proportion of players in professional hockey leagues. The advantage of being born earlier in the selection year is known as the relative age advantage or relative age effect.[5]

The Matthew effect is even seen in science. The Matthew effect is how our elite educational system cultivates future scientists and intellectuals. After graduation, scientists that receive recognition for research early on become more productive as their careers progress than scientists that didn't receive early recognition. Scientists with more impressive backgrounds have better employment opportunities, such as more employment at prestigious universities. Being employed at a major university gains more recognition than being equally productive at a less prestigious university. Scientists with more achievements and prestige get a larger proportion of funding, recognition, and citations. The advantages of trained capacity, structural location, and available resources make for more successive increments of advantage or disadvantage which make wide gaps between the haves and have nots.[6]

Operating on the principle that students with a disability have a disadvantage, the Matthew effect predicts a self-reinforcing inequality in possible achievements compared to their peers that are not disabled. Accommodations seek to level the playing field for students with disabilities and should be taken seriously.

3.3 Disability Support Services

The primary purpose of the DSS office is to act as a resource to enhance access to campus (see Chapter 2 on Disability Laws and Services for more detail). The DSS office has a crucial effect on whether students with disabilities have a positive college experience and will succeed. DSS offices have a legal mandate to provide access for SWDs, which is observed, but perhaps going beyond legal compliance to promote equity should be the standard.[2] This may in some cases require a creative approach to meet the unique needs of individual students. Creating innovative model accommodations reflects the university's commitment to diversity and equality of opportunity for persons with disabilities. When providing academic accommodations to students, access to the academic curriculum should be the first priority. DSS staff should be up to date with the newest techniques and technologies, and the latest in technological advances that would enhance access should be made available.

A common feature that persons with disabilities encounter is that the systems that provide accommodations that are needed can be undependable.[2,3] One of the important attributes of the DSS is ensuring that students receive the accommodations they need and that they are reliable and given in a timely manner. The accommodations that students with disabilities rely on can malfunction or may not be maintained properly. Manual door openers fail, audible crosswalks malfunction, wheelchair ramps become blocked with snow, circuits short, and equipment fails. Note takers, sign-language interpreters, CART providers, and access aids might miss work. “An accommodation system is stable if it has internal mechanisms that would quickly restore it to proper functioning if it were to fail.”[2] Ideally, DSS institutes system redundancy to prevent any disruption of operation and maintain a continuity of service. However, adding redundancy increases the cost and the complexity of the system. Instituting redundancy, particularly for physical accommodations, is cost prohibitive for most DSS offices and depends on a close relationship with the physical plant personnel. However, contingency plans should be in place and there should be periodic checks to make sure things are functioning properly. The transition period of a student with a disability not receiving an accommodation might not just be inconvenient. It could be the difference between a student passing or failing a class — or much worse. Think of what could happen if some seemingly insignificant detail like snow removal caused a student to get stuck and suffer from hypothermia. What would happen if a student was hit by a car because an audible crosswalk did not indicate which street was safe to cross? This raises the issue of the institution’s responsibility to keep the campus safe for all persons — including those with disabilities.

3.4 At the Beginning of the Semester

The point at which an instructor learns of the need of a student for accommodations will depend to a large extent on whether the student with the disability is a first semester freshman or one who has attended the college in previous semesters, since DSS must evaluate the need of that student for accommodations. In the best-case scenario, the new student will have met with DSS personnel at least several months before classes begin to start the process. In other cases, however, the semester may be well under way before accommodations are requested and approved, and subsequently DSS contacts the instructor. There may even be instances where the instructor notices that the student may need some help and proactively encourages the student to approach DSS. The instructor does not have the right to assume the need for help is because the student has a disability or to ask the student if there is a disability or what the

nature of the disability may be. At the college level, it is the student's right to reveal or even conceal the need for accommodations and health information. This is FERPA (Family Educational Rights and Privacy Act)[7] protected information, and it is solely the student's responsibility to reveal the need and share the accommodations with the professor/instructor.

Ideally, the student with a disability will initiate a preterm meeting with the instructor to discuss needs and how to implement the necessary accommodations recommended by DSS. At the very least, the instructor and student should meet to formulate a plan for the semester during the first few days of the term. The instructor can also consult with the DSS office to get additional information about approved accommodations for the course, if necessary. Formulating a plan before the semester begins familiarizes the instructor and student with each other's requirements so they can make any necessary arrangements.

Many physical accommodations to buildings that are meant to increase accessibility for individuals with disabilities actually benefit individuals without disabilities as well. Ramps replacing stairs, automatic doors, verbal announcements on elevators, and curb cuts make life easier for everyone. In a similar fashion, the suggestions in this section apply to students with and without disabilities, and as such can be implemented by instructors whether or not there is a student with disabilities in the class.

In general, students with disabilities should position themselves in the most suitable location in each classroom. That is usually a location with a clear view of the instructor and visual aids like whiteboards, screens, and TV or computer monitors. Accommodations, however, should be individually tailored for students with disabilities and to the physical set-up of the classroom. A ramped lecture hall with only a few aisles may limit seating options for a student using mobility aids, but also for the student who is uncomfortable when close to others because of anxiety or autism. A more traditional classroom may have desks too small or too closely spaced for the student using a wheelchair. The students themselves are the best source of information about their needs, as they know what works best.

Any class may include students who have difficulty speaking or asking questions in public. These difficulties may be compounded for students with disabilities. For example, students who are Deaf or hard-of-hearing may hesitate to speak in class if some people have misunderstood their speech in the past. They may also be concerned about understanding the teacher's reply or interrupting other speakers whom they do not hear. Similarly, students with language-based learning disabilities may have difficulty translating thoughts into words. Others may be nonverbal and use various electronic media for communication. These students may become socially isolated from the rest of the class members who may be unaware of their coping methods. Teachers can help by involving students with disabilities in classroom activities as much as appropriate. Encouraging all students to participate actively in class is an effective teaching technique that benefits all students. It can have particular benefits for students with disabilities. More information about communication impairments that affect participation in the classroom environment can be found in Chapter 8 and Chapter 9, on hearing and communication impairments, respectively.

In the same way, teachers can explore opportunities for multimodal instruction. Using different methods of imparting information accommodates different learning styles. It also reinforces

ideas and concepts given in lectures and textbooks and increases the likelihood of students grasping the material. Teachers have access to a wide variety of multimedia instructional technology from textbook publishers as well as on the internet in general. Some techniques, such as presentations on video and online learning, are especially helpful because students can access the content autonomously and at their own pace. Many of these materials are beneficial for group presentations because they may have options such as closed captioning that facilitate learning among students of all abilities.

Advance preparation and organization are among the hallmarks of a successful student. These traits are especially important to many students with disabilities. Those with mobility limitations, for example, may select only materials relevant to the day's lessons to carry with them to class. It is helpful to make syllabi, notes, and other course materials available in electronic format as far in advance as possible, through the institution’s learning management system (more on this in Chapter 4). This not only helps the student’s advance preparation, but also makes it possible to take all necessary materials on a laptop, tablet, or smart phone. Making course materials available in advance may be essential for students with Attention Deficit Hyperactivity Disorder (ADHD) or learning disabilities that affect time management and organization skills. Having course materials in advance is also valuable for nondisabled students with personal needs for efficient organization and time management. Among them are students who care for young children or other family members and students with significant job responsibilities. Often it is helpful for students to preview subject matter before it is taught in a lecture, recitation, or discussion session. Many other common teaching practices—helpful to all students—can be especially beneficial for students with disabilities. These include timely explanation of course requirements, objectives, and criteria and early announcement of deadlines for completing long-term projects and term papers. Facilitating advance preparation can make the difference between students learning the information in class or needing an outside tutorial.

3.5 Considerations during the Semester

Effective techniques for lecturing and facilitating classroom discussions help all students and are particularly important for teaching students with disabilities. The specific techniques depend on a variety of factors, including the specific needs of the students in the class, the size of the class, and the instructor's own teaching style. Instructors can use any or all of the following techniques to greatly enhance learning for students with many kinds of disabilities. These methods often reduce or eliminate the need for certain classroom accommodations because they follow "learning-centered" strategies that enhance in-class participation and academic performance for all students. These are some of the common technique strategies that can be implemented:

- **Make yourself accessible.** At the beginning of each term, inform students that you are available to privately discuss any issues or needs, including disability accommodations and personal issues that might impact progress in the course. Doing so invites students with disabilities to identify themselves early in the term without feeling singled out. Some instructors in relatively small classes schedule each student for a visit during the first week or two of the semester, again not singling out students with disabilities. Include on each course syllabus

approved language that your school would like you to use when referring students to the DSS office for an accommodation.

- **Syllabus.** Provide students with a course syllabus, written and/or published on the institution's learning management system, that includes due dates for assignments and dates for tests and quizzes. Doing so supports students' needs for advance preparation and gives the DSS office ample time to prepare alternate-format materials that students with disabilities may need. If any schedule changes become necessary, provide students with a written, updated syllabus that includes those changes.

- **Make course material accessible and readily available.** Provide access to lecture outlines and notes for students to refer to during class and allow the students to use electronic media during class to access the material. In many cases, this strategy may mitigate the need for an in-class note taker, particularly for students who are learning disabled, have ADHD, or are vision-impaired. The materials should be available online through the learning management system used at your school so that the students may make changes to accommodate their individual needs.

- **Think digital.** Prepare course handouts and make them available as digital documents. That will reduce the DSS office's time and expense in converting print materials into alternative formats. It may even allow the student to use the materials independently, removing the need for that type of assistance from the DSS office. All material should be in a format that can be accessed by screen reader technology. All videos should have closed captioning and, if possible, audio description.

- **Speak well.** In the classroom and the lab, speak as clearly as possible, face your students while talking, and use appropriate gestures. Take extra effort to speak at a moderate pace if you are accustomed to speaking rapidly or have an accent, or if you have students for whom English is a second language. This strategy supports optimum note-taking methods and in-class learning for all students. It is particularly helpful for students with certain learning disabilities, the Deaf and hard-of-hearing, ADHD, Attention Deficit Disorder, or psychological disabilities.

- **Introduce the content.** Introduce each lecture with a brief review of the previous class lecture to reinforce memory and cognition.

- **Go verbal and visual.** Use both verbal descriptions and visual aids to introduce major concepts and terminology. It will help all students learn and be especially helpful for students with learning disabilities, visual or hearing loss, or ADHD.

- **Clarify assignments.** Give assignments in both oral and written form to reach students with different learning styles.

- **Describe visuals.** Verbally describe or explain charts, diagrams, graphs, and other information being presented in a visual format. Doing so is critical for students with vision impairments but also reinforces learning for students with certain learning disabilities that involve visual processing disorders**.**

- **Demonstrate.** When possible, demonstrate new procedures to reinforce learning for students who process information either verbally or visually. Also, if possible and available, demonstrate new procedures using tactile demonstrations when appropriate. In the laboratory, demonstrate the proper use of glassware, equipment, and instruments. Use student molecular model kits or pass around large molecular models when discussing molecular structures.

- **Hold study sessions.** Encourage students to take advantage of the instructor's office hours for further clarification of classroom or laboratory topics and create study sessions to make it more inviting to students. Also, reinforce with the student that other resources are available to them such as supplemental instruction and tutoring.

- **Encourage peer learning.** Encourage the use of cooperative learning techniques, such as working in small groups, which reinforce many learning styles and encourage active learning. Encourage students to record lectures or choose partners to share and discuss the day's lecture notes. Encourage students to form study and discussion groups. Encourage peer learning and teaching, which promote active learning so that students can accentuate their individual strengths.

- **Let them volunteer.** Allow students to write answers and share with smaller groups before sharing with the class to reflect on their responses. This will give more students the opportunity to volunteer answers whenever possible, by allowing for differences in individual response times. Doing so minimizes anxiety and accommodates the different ways students process and respond to information; it also allows the students to become more confident in their responses. However, calling on random students to answer questions or solve problems in front of the class may exacerbate anxiety issues for students with learning disabilities in particular.

- **Focus on students.** Use teaching materials and approaches that focus on students' experiences, opinions, and reactions to provide a frame of reference for learning new concepts.

- **Use accessible technology.** Use technology that makes information more accessible, such as computers, assistive listening equipment, closed-captioned and audio description videos, CART,[8] and C-Print.[9]

- **Be assistive.** To the greatest extent possible, help students with disabilities with the accommodations approved by the DSS office, such as helping to recruit a volunteer or paid note taker, if asked.

Instructors should contact the DSS office for assistance regarding individual needs of students with disabilities and work with the DSS office to ensure that the student receives an effective education.

3.6 Taking Notes

Many disabilities make it difficult or impossible for a student to take effective notes during classroom and laboratory sessions. Instructors who routinely make their notes available to all students minimize this common barrier for students with disabilities. Remember that notes made available in digital format simplify the process of converting written material into Braille, audio, and other nonprint formats.

A number of accommodations can be used when the instructor's notes are unavailable. For instance, classmates may serve as note takers for students with disabilities, sharing their notes in the form of photocopies or laptop computer files passed by electronic media. Some students with disabilities can take effective notes simply by using a laptop computer in the classroom. Programs are also available for a student to record the class on a laptop, phone, or tablet, although the student should request permission from the instructor to make recordings. More formal note-taking arrangements are also available. These include using a paid note taker with prior course experience. DSS offices usually make formal arrangements for note takers. Most campus DSS centers are accustomed to providing note takers with an appropriate knowledge of chemistry. Some students who use a note taker may also benefit by recording the lecture and using the recording to review and make personal changes to the notes after class. Students who are deaf need to have recordings transcribed. Some DSS offices provide transcription services, and others can arrange for them.

Many instructors routinely post course materials on the internet. It is critical that the course website be accessible to students with disabilities, especially when it contains required material not readily available elsewhere. For students who are blind or have vision-loss, for instance, it is very important to provide an alternative text-only (ALT Text) format for web pages. Students can easily access that format with screen-reader software that converts text into audio. Screen readers cannot convert graphics into audio, so text descriptions of graphics also are important for an accessible web page. More information on this topic can be found in Chapter 4, Universal Design.

3.7 Testing and Evaluation

Few aspects of the academic testing and evaluation process are more critical — and yet the source of more misunderstanding and concern — than measuring the academic performance of students with disabilities. Students with disabilities should be evaluated with the same criteria and on the same scale as their classmates. This process often requires accommodations by the instructors, such as extended testing time, tests administered using recordings or other alternative formats, oral examinations, or testing in a quiet, distraction-free

room. It can lead to concerns over whether the accommodated testing process compromises academic standards.

For testing accommodations to be accepted and successful, faculty must feel confident that accommodations will not represent a lowering of standards or a separate set of standards for some students. A comparable question could be asked about giving a test to two sections of the same class, one meeting at 9 am and the other at 10 am. Giving the same test to both sections assures that the content and grading systems are the same, but the later class not only has an extra hour to study but has the possibility of learning some of the test questions before entering the test venue. On the other hand, trying to make two tests with a comparable level of difficulty is very difficult, and the potential effect of the time difference still exists. In the case of giving some students accommodations, testing all students under the same conditions may not be the fairest way to measure understanding and knowledge. The goal of testing is to measure knowledge of the subject — not the student's ability to grasp a pen, write quickly, read print on paper, or concentrate despite classroom background noise and other distractions. Unless accommodations are available to many students with disabilities, the testing process invariably becomes an evaluation of "knowledge plus" — knowledge of coursework, plus physical and psychological abilities. Accommodations in the testing and evaluation process are rarely burdensome for the teacher. Consider, for instance, the process for administering tests in an alternative to the standard print format. Instructors already have the basis for alternative formats in the digital file used to prepare the test. The word processor file can easily be modified to produce large-font versions for students with vision or learning disabilities. A student's speech-synthesizer software can "read" the file and convert it into audio. The file also can be converted quickly and economically into Braille. Generally, the instructor does not have responsibility for the actual conversion, which is done with the student's technology or by the DSS office.

Not all accommodations require a separate testing room. The decision to use a private room is made by the DSS office or the instructor, not only by the student. A separate room should be used only if the accommodation interferes with other students in a testing situation or the student has a disability that requires solitude in testing situations. Students with disabilities often can be tested alongside their peers by using methods that avoid distracting other students. For example, a student can wear an earplug to listen to a computer with speech synthesizer software that "reads" the test. Likewise, the student can remain in the main classroom while reading a Braille version of the test generated from the digital file.

A separate room may be important if the testing accommodation requires:

- A reader,
- A scribe,
- Extra time,
- A low distraction environment for the student,
- Extra desk space to spread materials,

- Special lighting,
- A Braille writer, which tends to be noisy,
- Access to electric outlets,
- Other assistive technology that is not located in the classroom, or
- Other activities that would distract classmates.

Some students with disabilities may need extra time to take tests and can be accommodated in the regular classroom if the room and instructor are free during the previous or following period. Time limits can present a tremendous competitive disadvantage to students with certain disabilities for reasons unrelated to their understanding of the material. The teacher, the student, and DSS personnel should work together to determine the amount of extra time that is reasonable.

In post-test classroom explanations of the correct answers, care is needed to ensure that all students can follow the often rapid-paced discussion, which may be difficult for students who are Deaf or hard-of-hearing or have learning disabilities.

3.8 **Past Accommodations as a Guide**

In high school, the student's Individualized Education Program (IEP) defines the appropriate testing and evaluation methods. Many are quite similar to the accommodations described above for post-secondary students. In college, it is the student's responsibility to request testing accommodations and work with the DSS office and, ideally, with the faculty member to find the most appropriate accommodations. The DSS office should then send a letter to the faculty member confirming that the student has a documented disability and is entitled to accommodations, listing the approved accommodations. Once this step is completed, the student still has responsibility for requesting the accommodations from the instructor, and the instructor has the responsibility of complying. The accommodations list is not etched in stone. It can be changed as the semester progresses and the student and instructor gain experience with the accommodations and the demands of the class. When accommodations are not sufficient, the student, faculty member, and DSS office staff should discuss alternatives.

Most postsecondary students who cannot take written examinations in the usual manner already have practical, workable, approved alternatives that worked well in their pre-college education. Given the nature of the course content, these alternatives may have been different for different subjects, for example, a literature course compared with a STEM course that has mathematical content. Particular attention should therefore be given to accommodations in STEM lecture and laboratory courses. The National Federation of the Blind's *Post Secondary Educational and Career Development: A Resource Guide for the Blind, Visually Impaired and Physically Handicapped* offers helpful suggestions on testing alternatives.[10]

It is important to seek information from the student about the best way he or she can demonstrate knowledge of the course material. Teachers working with a student for the first time may also wish to consult with colleagues who have experience in providing

accommodations. However, there is no substitute for a meeting involving the teacher, the college student, and DSS personnel.

In post-test classroom explanations of the correct answers, care is needed to ensure that all students can follow the often rapid-paced discussion, which may be difficult for students who are Deaf or hard-of-hearing or have learning disabilities.

Developing accommodations for students with disabilities can spark the creativity of instructors and encourage reevaluation of traditional approaches to testing and evaluation. Educators now realize that all students may benefit from a variety of assessment methods. Written tests are not the only way for students to demonstrate their grasp of a subject. Oral presentations, projects such as posters or models, group projects, take-home tests, and oral exams are among a rich assortment of alternative testing methods that may be appropriate for all students. Some of these methods may be particularly helpful for students with learning disabilities or ADHD.

3.9 In the Laboratory

Laboratory experience, a fundamental part of many scientific disciplines, is especially important for experimental sciences like chemistry. Most students with disabilities can work safely and effectively in the laboratory, using accommodations similar to those provided in the classroom. Scientists with severe disabilities, including total blindness, have verified that fact through long careers that involve teaching and working in academic and industry research laboratories. Some disabilities, however, may restrict a student's laboratory activities. The level of participation must be determined on an individual basis. It is important to remember that restricted laboratory activity does not necessarily preclude a productive scientific career. Automation and new technologies continue to reduce the need for physical manipulations. Students gain an appreciation of chemistry from lab experience that is vital to many careers in science and medicine. That experience also can be valuable in nontraditional chemistry careers that do not involve laboratory activity. Many successful chemists and other scientists—with and without disabilities—direct experimental programs without performing laboratory manipulations themselves. Indeed, senior scientists in academia and industry rarely set up apparatus or do other bench-side work. Other chemists with disabilities work in academic and industry laboratories with few or no accommodations.

Accommodations are very different for different disabilities, and even for students with the same disability. For that reason, Chapters 7–12 discuss the laboratory accommodations and adaptations needed for specific types of disability. Chapter 5 addresses the particular situation where a student has a service dog. Please read the appropriate chapters to get specific information.

3.9.1 General Laboratory Considerations

Certain considerations apply to all students with disabilities. Before the first laboratory session, the teacher should meet with the student, laboratory instructors, safety personnel, and others who will be involved in lab sessions. The meeting, which may be held in the lab, is an ideal forum to discuss physical accessibility and safety of lab facilities, accommodations, and

procedures. It should also establish a mechanism to ensure that all parties communicate regularly during the academic term.

Some lab courses require that students work in pairs or groups. In these cases, the instructor should offer to help arrange a congenial lab partner or group, and check occasionally to be sure the arrangement is working well. The best lab partner will probably be an above-average student, who can spend time doing the extra physical tasks and still finish his or her own experiments successfully. If a student has a visual or communication disability, a lab partner with strong verbal skills may be best at relaying instructions and other important class information. However, the arrangement should be equitable for all students and it is important that the "chemistry" between the students works. When the student with disabilities needs extensive assistance, it may be more effective to employ a full-time laboratory assistant. The assistant may be a more senior student who has taken the course previously.

The student may need extra time to complete lab assignments, and the teacher can consider several options. For instance, the student might begin the regular section earlier and stay later or complete the work during another scheduled laboratory section. The student and instructor should agree on the amount of extra time that is reasonable, in accordance with DSS office recommendations.

3.9.2 Directed Laboratory Assistants

A directed laboratory assistant is an individual who performs the physical manipulations of an experiment under the student's direction. Directed laboratory assistants provide physical assistance in completing laboratory assignments. They should not prompt, give hints, or otherwise interfere in the student's learning experience. The student should direct the experiment, observe data acquisition, and interpret the data. The assistant may be needed to manipulate instruments, equipment, or materials. For example, a student who is unable to use his or her hands because of a disability could direct a laboratory assistant in the following ways: The student tells the assistant to open a designated reagent bottle and pour a specific amount into a graduated cylinder. The student directs the assistant to pour some out or add more, with the student deciding when the meniscus is at the correct level. Then, the student indicates to the assistant the container into which the liquid is to be poured. The student also tells the assistant when and how much the reagents should be heated, whether to stir and with what, and so on. Directed laboratory assistants may also assemble and disassemble apparatus as directed by the student and perform other physical tasks not possible for the student with disabilities. This approach is much the same regardless of the student's disability.

Instructors should clearly establish the role of the assistant and the relationship between student and assistant before the first lab session. The student does the thinking and directs the assistant but should be as independent as possible. The assistant should do exactly as the student directs, unless it would be unsafe. The instructor should confirm that the assistant fulfills this role properly. When questions arise, the student and instructor should confer directly with the student, not through the assistant.

The assistant should be an individual who has already taken the course, rather than a student currently doing so, in order to be familiar with the equipment and terminology. Students with a vision impairment should be given an opportunity before or during the lab session to feel and visualize how the equipment is set up. In some cases, such as allergies or some other sensitivity, the student may direct the assistant remotely. This can be done by using current video technology on networked computers or other ways that allow the student to view the experiment from a different room and communicate with the assistant. Use of a lab assistant should never affect the student's grade.

3.9.3 Laboratory Safety

Any institution, including educational institutions, needs to take people with disabilities into consideration when creating a safe environment. The best safety measures focus on the prevention of accidents, planning for accidents, conducting drills, and mitigating the consequences of accidents. The RAMP method, developed by David Finster, Ph.D., and Robert Hill, Jr., Ph.D., and promulgated by the ACS Committee on Chemical Safety, provides an excellent framework for evaluating hazards in the laboratory and minimizing risks. The acronym RAMP stands for *Recognize* the hazards, *Assess* the risk of the hazards, *Minimize* the risk of the hazards, and *Prepare* for emergencies from uncontrolled hazards.[11] The premise is that it is easier to prevent an accident than repair the consequences afterward. Rules can be made to prevent accidents, but a more efficient approach is to make safety part of the workplace culture.

Simple steps can help ensure safe participation of students with disabilities in the laboratory. Instructors, for instance, should encourage the student to visit the lab before the first session, noting the location of exits, showers, fire extinguishers, and other safety equipment. That advance knowledge will encourage the student to participate more effectively in the safety-orientation program. Instructors also should discuss and address laboratory-specific needs. Clear paths to exits are always required, and vigilance about this is essential for a student with mobility limitations or a student with a visual disability. Determine whether the student can read labels on reagent bottles and instrumentation. Students with learning disabilities or ADHD may have difficulty doing so, as well as students with visual disabilities. These students may benefit from labels printed in larger fonts, Braille, or raised-letter type. Work with each student to determine whether certain operations may be too risky to perform without assistance. Strongly encourage all students, particularly those with vision disabilities or poor manual coordination, to wear appropriate protective gloves when working with chemicals. For more discussion about choosing gloves, see the ACS booklet, *Safety in Academic Chemistry Laboratories (SACL).*[12] Information about making the laboratory a safe environment for students with specific disabilities can be found in Chapters 7–12 of this eBook.

When planning new lab facilities, there should be "safe refuge areas” constructed, usually on or near a stairwell. These are special fire-safe structures where individuals (both disabled and nondisabled) who are unable to leave the building can take refuge until rescuers arrive. Such areas can benefit people with and without disabilities in fires, explosions, or natural disasters. In an older building without fire-safe refuges, security and emergency personnel should work with the department to identify the safest areas in which individuals can wait for help. If an evacuation is necessary, security and emergency personnel should be immediately notified of

the number of people in the refuge area and of any special accommodations needed. In some cases, individuals with mobility impairments may need to be evacuated using an evacuation chair down stairwells, and this eventuality requires prior discussion with the individual and training for security and emergency personnel.[13] Instructors and security departments should be aware of students who may need assistance in evacuating the lab. DSS personnel should inform the instructor when such students are in the class. Instructors should ask these students what assistance will be needed in case of an emergency or evacuation and ensure that security departments also have that information. Considerations should be made if the class needs to be removed from the building for extended periods of time.

Instructors and students alike should be aware of the location of all safety equipment, signs, alarms, and exits in the laboratory. Larger laboratories should have at least two unblocked exits leading out into different areas of the corridor, but small individual research labs may have only a single exit. The instructor should know the primary and alternate evacuation routes, since some areas may be unusable in an emergency. Know the location of fire extinguishers, emergency gas and electricity shutoffs, eyewash stations, safety showers, and emergency phones. Equally important is knowing how to use the safety equipment, such as various types of fire extinguishers. Exits must have emergency signage, alarms must be both visual and audible, and emergency routes should have emergency lighting. In the unlikely event that the instructor is not present when an emergency occurs, students should also be fully trained in emergency procedures. Students with disabilities should be able to access and use all of this equipment.

3.9.4 Emergency Evacuation

Drills allow faculty, staff, and students to be ready if an emergency requiring evacuation does occur and allow familiarity with primary and alternate routes of evacuation. During evacuation drills, the instructor should practice evacuation of all students, with particular attention to the needs of those with vision or mobility disabilities. Drills should be done under conditions likely to prevail during an actual emergency, when elevators and mechanical doors may be unusable or inoperable.

In an actual emergency, instructors should follow the specific evacuation plan developed by their own institution for the individual laboratory or building, as appropriate. The plan itself must consider the needs of individuals with and without disabilities. The following additional steps are of particular concern where there are individuals with disabilities in the area to be evacuated:

- Immediately notify the emergency services of the number of individuals with disabilities and the plan for their safety.
- Assign a partner to guide each individual who can safely exit the area to the meeting point, using the evacuation route.
- If an individual cannot exit the area because of the nature of the disability, a partner should be assigned to bring that individual to the predesignated area of safe refuge and wait until rescue arrives.

- Have a responsible individual in the safe refuge area to communicate and coordinate with emergency personnel.

SACL[12] gives excellent information on dealing with emergencies of all types in the chemistry laboratory. Every instructor and student should be familiar with its content.

3.10 References

1. Understanding Accommodations. *IRIS Center*, 2022. https://iris.peabody.vanderbilt.edu/micro-credential/micro-accommodations/p01/ (accessed 2023-07-21)

2. Marshak, L.; Van Wieren, T.; Ferrell, D. R.; Swiss, L.; Dugan, C. Exploring Barriers to College Student Use of Disability Services and Accommodations. *J. Postsecondary Educ. Disability* **2010**, *22* (3), 151–165. Family Education Rights and Privacy Act (FERPA). *U.S. Department of Education.* https://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html (accessed 2023-07-21)

3. Students with Disabilities in Higher Education. *Postsecondary National Policy Institute*. https://pnpi.org/wp-content/uploads/2021/10/StudentswithDisabilities_October2021.pdf (accessed 2023-07-21)

4. Briggs, S. The Matthew Effect: What Is It and How Can You Avoid It in Your Classroom? *informED*, July 1, 2013. https://www.opencolleges.edu.au/informed/features/the-matthew-effect-what-is-it-and-how-can-you-avoid-it-in-your-classroom/ (accessed 2023-07-21)

5. Nolan, J.E.; Howell, G. Hockey success and birth date: The relative age effect revisited. *Int. Rev. Sociol. Sport*. **2010**, *45* (4), 507–512. DOI: 10.1177/1012690210371560 (accessed 2023-07-21)

6. Bol, T.; De Vaan, M.; van de Rijt, A. The Matthew effect in science funding. *Proc. Natl. Acad. Sci. U. S. A.* **2018**, *115* (19), 4887–4891. DOI: 10.1073/pnas.1719557115 (accessed 2023-07-21)

7. Family Education Rights and Privacy Act (FERPA). *U.S. Department of Education.* https://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html (accessed 2023-07-21)

8. Captioning and CART. *Hearing Loss Association of America.* https://www.hearingloss.org/hearing-help/technology/cartcaptioning/ (accessed 2023-07-21)

9. C-Print Captioning Services. *Speech + Deaf Center. htttps://hearingspeechdeaf.org/print-is-a-speech-to-text-service/* (accessed 2023-07-21)

10. National Federation of the Blind. *Post Secondary Educational and Career Development: A Resource Guide for the Blind, Visually Impaired and Physically Handicapped*; National Federation of the Blind: Baltimore, MD, 1981; cassette LSA04C N/C; print LSA04P.

11. Hill, R. H.; Finster, D.C. *Laboratory Safety for Chemistry Students*; John Wiley & Sons, Inc., 2010; pp 1–7.

12. *Safety in Academic Chemistry Laboratories*, 8th ed.; American Chemical Society Committee on Chemical Safety, 2017. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf (accessed 2023-07-21)

13. Stairwell use during an emergency. *Office of Disability Employment Policy*. https://www.dol.gov/agencies/odep/publications/reports/stairwell-use-during-an-emergency (accessed 2023-07-21)

Chapter 4: Universal Design: Accessibility for Everyone

Maria Dulay,[1] George Heard,[2] Debra Feakes,[3] Pedro Flores Gallardo,[4] and Theresa L. Windus*,[5]

[1]Department of Radiology, Stanford School of Medicine, Stanford, CA 94305
[2]Department of Chemistry, University of North Carolina Asheville, University Heights Asheville, NC 28804
[3]Shaheen College of Arts & Sciences, Department of Chemistry, University of Indianapolis, Indianapolis, IN 46227
[4]8661 E. Pomegranate Street, Tucson, AZ 85730
[5]Department of Chemistry, Iowa State University and Ames National Laboratory, 125 Spedding Hall, Ames, IA 50014

***Email: twindus@iastate.edu**

Chapter 4 Contents

4.1 Introduction
4.2 User-Friendly Emphasis
4.3 Universal Design for the Classroom
4.4 Universal Design for the Lab
4.5 Universal Design for the Internet and Electronic Media
4.6 Electronic Resources for Teaching
4.7 References

4.1 Introduction

Terms like "disabled" and "able-bodied" create an unfortunate all-or-none misperception about human ability. People are not either able-bodied or disabled. Rather, human beings display varying degrees of physical ability. Some correlate with stages in the human lifespan. Robust men and women in their adolescent years, 20s, and 30s generally can accomplish a wider range of physical tasks, and do them with greater ease, than children or older adults. An individual's level of ability is not fixed, but often highly variable, constantly changing with time. For most people, those changes occur slowly, as age claims its inevitable toll on muscle strength, hearing, vision, and mental agility. Ability can also transition from one level to another abruptly because of accidents or serious illnesses. Being "able-bodied" is a temporary human condition.

Universal design is a philosophy of accessibility for all. It calls for making all objects, buildings, indoor environments, landscapes, and other places accessible to and usable by the greatest number of people to the greatest extent possible—regardless of their degree of ability or disability. For an academic institution, that means accessible school grounds or campuses, buildings, rooms inside buildings, equipment and facilities inside rooms, course content, websites, and other information products networked throughout the institution.

For example, an ordinary lever-type door handle, operated with a pushing action, is the epitome of universal design. The young child, the older adult with arthritis, the laboratory instructor carrying equipment, and the student with limited hand movement all might have difficulty grasping and turning a round door knob. The lever handle, in contrast, works easily with a push of the hand, nudge of the hip, or bump of a wheelchair. More people can reach electric outlets placed a few inches higher above the floor without needing to bend or stretch. Adjustable shelves, office chairs, countertops, and clothing rods all have an inherently universal design.

The principles of universal design incorporate many of the most common accommodations used by individuals with disabilities. At the same time, they make everyday activities easier and safer for everyone. Universal design is economical for several reasons. Universal design in the laboratory allows the greatest flexibility because items are not adapted to a particular disability but have a broad application. It is generally less expensive to design with accessibility for all users in mind than to convert an existing setting to make it more accessible. In addition, the quality of access is far superior when accessibility is incorporated into the structural design from the beginning. Poorly designed science classrooms and laboratories, for instance, can require more significant accommodations for students with disabilities. However, universal design principles applied during reconstruction or remodeling usually result in facilities usable by students with disabilities with little, if any, additional cost.

The 7 Principles of Universal Design

The 7 Principles of Universal Design were developed in 1997 by a working group of architects, product designers, engineers, and environmental design researchers, led by the late Ronald Mace at the then Center for Universal Design.[1,2] Since that time, these principles have been adopted by many centers and architects as enabling accessible environments. The following include the principles with selected examples.

Principle 1. Equitable use

- Design benefits people with diverse abilities and provides the same means of use for everyone, which should be identical when possible or equivalent when not.
- Avoids the segregation or stigmatization of any user.
- Provisions for privacy, security, and safety should be equally available to all users.
- Workstations should be ready to use immediately without summoning maintenance personnel.
- Provides support for portable assistive technology tools or devices.
- Ready-made workstations for assistive technology like network connections, speakers, and other devices.
- Design should be welcoming and appealing to all users.

Principle 2. Flexibility of use

- Accommodates a wide range of individual preferences and abilities.
- Provides choice in methods of use.
- Accommodates right- or left-handed access and use.
- Uses adjustable-height workstations.
- Provides easy access to utilities.
- Facilitates the user's accuracy and precision.
- Adapts easily to the user's pace.
- Provides moveable chairs and tables that can be reconfigured easily.
- Uses variable lighting and, where possible, natural light to control glare.
- Provides adjustable writing surfaces, like chalkboards, so writing surfaces can be individually tailored.
- Includes an instructor's workstation viewable from all locations in the lab.

Principle 3. Simple and intuitive

- User-friendly and can be easily used regardless of the individual's experience, knowledge, language skills, or current level of concentration.
- Eliminates unnecessary complexity.
- Consistent with user expectations and intuition.
- Accommodates a wide range of literacy and language skills.
- Arranges information in a manner consistent with its importance.
- Provides effective prompting and feedback during the task and after completion.
- Color-codes controls and outlets. A fume hood, for example, uses blue as the color for both the gas control handle and the nozzle inside the hood where the gas comes out.
- Places controls in a logical location and in a consistent manner

Principle 4. Perceptible Information

- Communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
- Communicates in different modes, including pictorial, verbal, and tactile, for redundant presentation of essential information.
- Provides adequate contrast between essential information and its surroundings.
- Maximizes the readability and appearance of essential information.
- Differentiates elements in ways that can be described, making it easy for the instructor to give instructions.
- Provides compatibility with a variety of techniques or devices used by people with sensory disabilities.
- Uses labels in Braille as well as a large, high-contrast font.
- Differentiates controls of more dangerous utilities (e.g., steam) from others with tactile differences.
- Provides high-contrast visual cues to identify changes in levels and edges of horizontal surfaces such as on the edges of counters or any place the floor level deviates.

Principle 5. Tolerance for error

- Minimizes hazards and the adverse consequences of accidental or unintended actions.
- Arranges elements to minimize hazards and errors; groups most-used elements in the most accessible area; eliminates, isolates, or shields hazardous elements.
- Provides warnings of potential hazards and errors.
- Includes fail-safe features.
- Discourages unconscious action in tasks that require vigilance.
- Ensures that safety equipment is usable by people with all levels of capabilities.
- Enhances alarms, for things such as airflow, so that they provide auditory, visual, and even physical cues.
- Provides safe placement and transport of materials.
- Provides a safety trough to catch liquid, to prevent spills on legs that do not have sensation.

Principle 6. Low physical effort

- Use is efficient and comfortable and with a minimum of effort and fatigue.
- Allows users to maintain a neutral body position.
- Provides equipment that can be operated with reasonable strength.
- Minimizes repetitive actions.
- Minimizes sustained physical effort.
- Makes sure utilities require less than 5 pounds of pressure to operate.
- Makes sure hardware is operable with a stick or without grasping.
- Places controls within easy reach.

Principle 7. Size and space for approach and use

- Enables people with different body sizes, postures, and degrees of mobility to approach, reach, manipulate, and use equipment and facilities.
- Provides a clear line of sight to important elements for any seated or standing user.
    - Makes the reach to all components comfortable for any seated or standing userAccommodates variations in hand and grip size.
    - Provides adequate space for the use of assistive devices or personal assistants.
    - Provides adjustable-height workstation for people of different heights or in different height wheelchairs and varying heights for alternative research goals.
    - Ensures accessibility and safety, with aisles that are clear and adequate for exiting.

4.2 <u>User-Friendly Emphasis</u>

Clarity in labeling, intuitive use, and decreased dependence on reading skills are aspects of universal design. For example, students with disabilities must be able to use fume hoods safely when they are required for a laboratory exercise. Unfortunately, persons with mobility disabilities cannot easily use most older-model fume hoods. Students with limited vision or learning difficulties may also find fume hood controls and functions difficult to use. A walk-up, floor-to-ceiling fume hood, in contrast, can meet the needs of all students.

Universal design results in lab facilities that are user-friendly, safe, and easily reconfigured for changing research or teaching needs. They also can be used for extended periods without renovation. Everyone benefits from a design that is easier to use, as illustrated by the "curb cut" phenomenon. When curb cuts were put in sidewalks to facilitate wheelchairs, they were found to be a boon to parents with baby carriages, bikers, skaters, and the elderly. The flexibility of similar simple design changes accommodates many different users and many different uses.

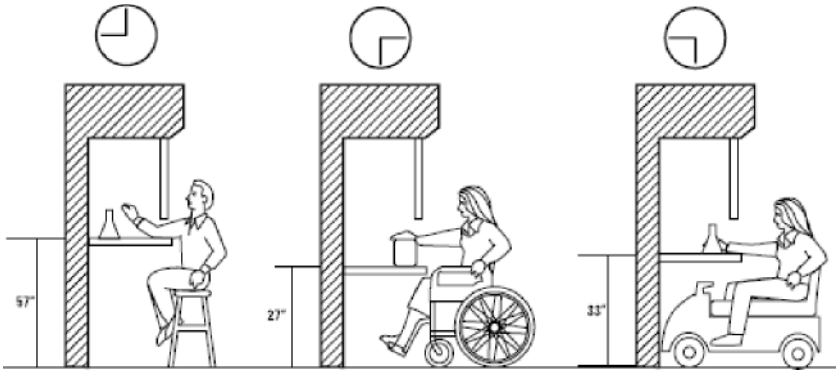

Figure 1. Adjustable-height laboratory fume hoods enable students in many situations.

Adjustable-height laboratory fume hoods are one example (see Figure 1). They can be used by students in wheelchairs, as well as tall or short people who may work seated or standing. Other examples include adjustable-height laboratory benches and modular furniture, which can be reconfigured for wheelchairs, different instruments, research tasks, and other applications. Such designs can extend the lifetime of a laboratory, which can be reconfigured at little or no cost for uses and users that were not anticipated during initial construction.

4.3 Universal Design for the Classroom

Universal design for the classroom involves the seven principles listed above and are geared toward creating a fully accessible learning environment for all learners. As will be discussed more in the following chapters, there are different actions that an instructor can take to make the class more accessible to all. For example, ensuring that the instructor is always facing the class when talking about a subject can help students who lip read to access the spoken component of the classroom. This does also help hearing students since the content will be projected out to the room instead of into a whiteboard or a projection screen. Having a room where the furniture is movable and can be adapted for different purposes also helps all students and accommodates different teaching styles as well. Since Chapter 3 discusses some of the basic considerations and the chapters below address many specific issues associated with different types of disabilities, this section will outline some of the basic ideas and the reader is referred to the other chapters.

The idea of Universal Design for Learning (UDL) has boiled the seven principles listed above down to three major guidelines to help in learning environments.[3] These are (1) Engagement - motivating and inspiring students to learn, (2) Representation - presenting material in different ways, and (3) Action & Expression - differentiate the ways that students can express what they know. The ideas are to be flexible and to use student cues to provide an active and accessible learning environment for all. Some examples of using UDL in the classroom include knowing your students' strengths and weaknesses, using digital material when possible (more on this later in the chapter), sharing content in a variety of ways, offering choices for how students demonstrate their knowledge, taking advantage of software supports, using low and no tech options to remove barriers, and learning from others.[4] It is important to note that students with disabilities have often built their own strategies for how to access materials or make the classroom setting optimum for their learning. Being open to adjusting as much as possible to enable all learners is a key to making the classroom environment equitable.

4.4 Universal Design for the Lab

Some characteristics of a laboratory that incorporates universal design include the following:[5-7]

- Adjustable-height storage units and special-equipment workspace. Pullout or drop-leaf shelves or countertops for auxiliary use can be included, such as shelves at lapboard height for holding instruments to be used by students in wheelchairs.
- Single-action lever controls or blade-type handles rather than knobs for people with impaired manual dexterity.
- Flexible connections to electrical, water, and gas lines for students with limited reach, such as those in a wheelchair.
- Alternative means of storage, such as a portable "Lazy Susan" or a storage cabinet on casters.
- Lever-type handles substituted for knobs that require grasping with a hand and turning with a wrist, for water, gas, and steam lines.
- Controls located on both the right and left sides for utilities, for the benefit not only of people who are impaired on one side of the body but also for those who are merely left- or right-handed.
- Tactile cues for potentially dangerous arrangements or situations, which benefits individuals who are vision-impaired or have learning disabilities.
- Accessible acid storage or solvent storage shelves that go under a floor-to-ceiling fume hood and can include a bottom shelf as a drawer. When combined with adjustable height tables, this allows a typical fume hood to be modified for many different uses, from organic synthesis to microbiology settings.
- Utilities that can be relocated to workstations used by students with disabilities.
- Sinks with flexible connections for use in adjustable-height fume hoods and with laboratory benches.

Chemistry departments should give most serious consideration to embracing universal design in the construction of new laboratory facilities and the renovation of existing labs.

4.4.1 Architectural Modifications

Other accommodations, including physical modifications to the lab, might be necessary. These are discussed in each of the chapters associated with specific disabilities. An excellent source of additional information about laboratory resources, techniques, and accessible chemistry laboratory experiments is Disabilities, Opportunities, Internetworking, and

Technology (DO-IT).[8] Modifications may require ingenuity on the part of the small school or department with limited resources.[9] There may be aspects of a given laboratory exercise that the student is unable to perform because of physical or safety considerations. Such situations probably will be rare and certainly should not prevent overall student participation in the laboratory. Students and faculty should work together on a solution for that one aspect of that one experiment, rather than scrapping the entire experiment.

Students should take an active role in ensuring that their needs will be met in the laboratory. If the instructor does not hold a conference before the first lab session, the student should request one. The student should visit the lab to make sure the area is accessible, learn about laboratory exercises beforehand, help faculty identify necessary accommodations, and help identify ways to fully participate.

Students with disabilities generally need access to the same accommodations during classroom testing, regular laboratory sessions, and lab practicums. Volunteer or paid lab assistants, for instance, can function in the same capacity without providing direct assistance in answering examination questions. Assistive technology that interfaces with lab instruments, computers, and other devices should also be available for students during examinations. Likewise, students who require extra time to complete regular experiments should have extra time for practicums. Instructors can use the same arrangements that have been successful during regular labs, such as allowing the student to begin earlier, work later, or complete the practicum in another section of the same lab. Likewise, procedures used during classroom testing also can serve as models for the practicum. For instance, students given tests in alternative formats - such as Braille, large print, or recordings - should have practicum materials in the same format. The overall goal should be the same as in classroom testing, so that the practicum fairly evaluates the student's knowledge of the subject material, independent of variables like physical strength, visual acuity, or mobility.

4.4.2 Basic Requirements

Complete ADA Accessibility Guidelines were first published in 1991 and have been revised several times.[10] The detailed guidelines with diagrams and other graphics can be downloaded from the Architectural and Transportation Barriers Compliance Board, an independent federal agency devoted to increasing access for individuals with disabilities and widely known as the Access Board. The Board's website is an excellent source of additional information.[11]

The Access Board's guidelines should be regarded as the most current and comprehensive and should be consulted before making architectural changes in a laboratory. However, the basic accessibility and safety requirements for laboratories used by individuals in wheelchairs include the following:

Aisles. Aisles must be at least 48 inches wide and clear of obstructions to allow sufficient room to maneuver a wheelchair. Where aisles are too narrow, a lab station can be set up at the end of the bench or a portable station can be positioned in an accessible area. A student with limited mobility should be assigned to a lab station on an outside aisle, close to an accessible exit, whenever possible. Each aisle must have two exits, each with a turning radius of at least 60 inches.

Aprons. When working with chemicals, all students should wear plastic or rubber (impermeable) aprons to protect their clothing. Students who use wheelchairs, or those who have no sensory perception in the lower body, should be advised of the importance of properly protecting their laps while working with chemicals.

Drawers. Drawers should be equipped with handles, not pull knobs, and designed so they can be opened with a stick or with a tug attached to the handle.

Eyewash stations. They must be located along an accessible aisle. Eyewash stations should be easily accessible to the wheelchair user. The American National Standards Institute requires that eye and face wash units and emergency showers be reachable within 10 seconds, which means that the workstation should be within a few meters of these safety installations.[12] In addition, the station should be plumbed at a lowered sink so the water does not pool in the student's lap. Chapter 10.5.6 has more detailed information concerning shower and eyewash stations for students with mobility impairments.

Face shields. A seated student's face may be at the same level as an experiment. A full-face shield may be warranted for certain experiments where safety glasses alone would not provide adequate protection. Another alternative is a properly supported bench shield.

Fire extinguishers. Lightweight fire extinguishers should be accessible to students with limited strength or mobility. All students should be instructed in fire drill procedures and the use and limitations of fire extinguishers. Of course, rules concerning fire extinguisher training and handling are determined by the institution and those rules take precedence to this recommendation.

Fume hoods. An accessible fume hood must be available when the student with disabilities is doing experiments that require a hood. Adjustable-height fume hoods are available and allow all students to work at a comfortable height. Ideally, the fume hood should be designed so that the student in a wheelchair can approach and use it in a head-on position. Walk-in hoods, if available, may be useful for some students who use wheelchairs. The student can sit at a portable table of appropriate height placed inside the hood.

Retractable drench hose. Many labs have drench hoses installed. Drench hoses resemble the spray hose on a kitchen sink and should deliver a low-impact water spray that avoids mechanical injury to the user (especially to the eyes). These hoses should be used as a last resort in the case of a large spill when other options are not available. In the case of a large spill that contaminates skin or clothing, a drench hose may be difficult since they are not generally hands-free, making removal of all contaminated clothing and jewelry difficult. If a retractable drench hose is installed, a typical safety shower with a long pull chain, as described below, still must be available.

Safety showers. These must be located along an accessible aisle at an appropriate height and equipped with an eyewash unit. Safety showers should have a pull-chain that reaches within 3 feet of the floor in case of the unusual event where a wheelchair user must get out of the wheelchair because of a chemical spill in the chair.

Sinks. Sinks must be readily accessible. This is often best accomplished by assigning the student with limited mobility to a workstation with or near a sink.

Transporting hazardous materials. If a student in a wheelchair carries hazardous materials for an experiment, the instructor should ensure that this is done safely. In general, we do not recommend that a student in a wheelchair carries hazardous materials on their lap or a tray. Reasonable options include using a small, wheeled cart to transport the materials or having a lab assistant transport the materials to the lab station. As noted above, the student should always wear an impermeable apron for safety in the laboratory.

Utility and equipment controls. They must be within easy reach.

Valves and door hardware. They should be operable with less than 5 pounds of pressure.

Workstation surfaces. The top of the work surface must be 30 inches from the floor. The bottom should have a 29-inch clearance and be adjustable to up to 34 inches (this will accommodate most power wheelchairs). The depth should be at least 20 inches with a maximum of 25 inches, and the width at least 36 inches.[13]

Some students with disabilities may require additional time to complete lab assignments. Laboratory exercises that minimize the need for students to move from location to location can facilitate the progress of all students, especially those with disabilities. Likewise, microscale experiments can be of benefit to all students by minimizing the risk of chemical exposure, reducing the volume of wastes, and lowering the costs of chemicals and waste disposal. However, this must be balanced by the challenges that might be presented for a student with fine motor impairments.

4.4.3 Meeting Specific Needs

Both undergraduate and graduate students involved in active research programs may require other modifications. These, however, need not necessarily be elaborate or expensive. Often, simple modifications of workspaces or adaptive equipment can suffice. One chemist who uses a wheelchair performs some experiments on a standard vacuum rack. This 22-inch-high, 12-inch-deep workspace provides the vertical access required by a seated individual for doing titrations, distillations, and column chromatography.[14] However, this workspace is not suitable for operations that require a fume hood. A biochemist who has a short stature uses a simple wood step-up platform, constructed at minimal cost by university maintenance personnel.[15] Nonmagnetic wheelchairs and easily fabricated sample handling devices can be used in nuclear magnetic resonance spectrometer facilities, where high-field magnets preclude the presence of magnetic objects.[16] Iron-containing bolts and other magnetic parts in aluminum or composite wheelchairs can easily be replaced with off-the-shelf stainless bolts. Alternatively, other students can assist wheelchair users by loading samples for NMR analysis. For wheelchair-using students involved in materials, chemical electronics, and nanotechnology research, wheelchairs can be adapted for use in clean rooms. Supplemental funding is available for such adaptive equipment in research grants from most major funding agencies.[17,18]

In the instructional laboratory, accommodations can easily be developed for specific laboratory operations. One example involves experiments with a burette. If no suitably low work surface is

available for reading the burette at eye level, a lab partner or assistant could lower the burette for the student to read. Of course, this must be done with care. Since this might introduce a large source of error, another method might be to weigh the flask before and after the titrant is added. A conversion to volume then can be made by using the density. When the burette top is beyond the reach of the wheelchair user, fellow students can help by adding reagents. Placing the burette in a tray in the bottom of a lab sink with the drain plugged may lower the apparatus enough for a seated student. Likewise, the student in a wheelchair can use alternative techniques for experiments involving classic column chromatography. A centrifugal chromatography system (e.g., a chromatotron or cyclograph) can be used if the desired compound has a chromophore. Flash cartridge chromatography systems may provide another suitable alternative.

These technologies are standard in most industrial laboratories, and bringing them into the instructional or academic research laboratory will enhance the educational experience for all students, with and without disabilities. Instructors should focus on the goal of the experiment,

which may be purification of a chemical compound, not the manner in which it is achieved. Many alternative routes to the goal may be more suitable for a wheelchair user.

It should be noted that laboratory automation, such as the use of robots, is becoming commonplace in both academic and industrial settings. It results in greater speed, efficiency, and capacity. The application of laboratory automation tools can enhance the productivity of students with limited mobility, and in some cases even remove the need for accommodation.

These approaches to making a laboratory more accessible have been used successfully by various scientists with disabilities. More options will become available as technology improves. For example, some students will benefit from innovations in standing chairs or adjustable-height wheelchairs, which are now on the market. This technology also may have potential applications in the laboratory, with or without modifications.

4.5 Universal Design for the Internet and Electronic Media

The internet has opened a new realm of information, communication, entertainment, shopping, and other resources that are available around the clock without leaving the home, office, or dormitory room. This easy access to such a powerful communications tool – useful for everyone – can be extraordinarily helpful for individuals with physical disabilities. It truly does put the world at our fingertips, requiring just a glance of the eye, a click of the mouse, or an ear to the audio. All those benefits are available, that is, to individuals who can see a computer monitor, manipulate a mouse, hear the audio, distinguish among a variety of colors, and perform other tasks needed to access web content.

Approximately 13% of all Americans (about 42.8 million people) have an identified disability.[19] Research suggests that people with disabilities experience significant limits to access of the very web content that could be so beneficial.[20] Students with disabilities do have access to screen readers that convert screen content to audio, software that magnifies screen content, and other assistive technology to facilitate their use of the internet. But many barriers to accessing web content still exist. Consider the following example, adapted from WebAIM, of

the difficulties that a simple tabular course schedule poses to students with vision disabilities who use a screen reader.[21]

Course number	Department	Time	Days	Credits	Classroom	Instructor
300	INST	2:00	MWF	3.0	DFB 378E	Smith
120	PHYS	11:30	TR	3.0	GRB 228	Jones
214	PSY	10:00	MW	3.0	DFB 214A	Collinwood

In producing an audio version of the table, a screen reader might say the following: “Table with seven columns and four rows. Course Number, Department. Time. Days. Credits. Classroom. Instructor. Three hundred. Inst. Two o'clock. M. W. F. Three point oh. D. F. B. Three hundred seventy eight E. Smith. One hundred twenty. Phys. Eleven thirty. T. R. Three point oh. G. R. B. Two hundred twenty eight. Jones. Two hundred fourteen. Psy. Ten o'clock. M. W. Three point oh. D. F. B. Two hundred fourteen A. Collinwood."

Assistive technology did convert web content from an inaccessible form (visual data) into another (audio) that is accessible to the student with a visual disability. But the information still may not be fully accessible.

Trends in web page design and applications have introduced new problems for existing assistive technologies. These include the more extensive use of web page graphics, which can't be translated by a screen reader; the introduction of increasingly complex graphics; and the wider use of multimedia features that require good eyesight and hearing.

4.5.1 Why Make Internet Content Accessible?

Internet content should be accessible to students with disabilities for the same reasons that buildings, classrooms, laboratories, and other items should be accessible. It's the right thing to do. Access to web content should not be limited to individuals with certain physical attributes. It's the law for federal agencies: Section 508 of the Rehabilitation Act requires that internet content and other information technology developed, bought, or used by the federal government be accessible (see Chapter 2 for more information).[22] Regulations implementing Section 508 took effect in mid-2001 and were expected to have broad influence in encouraging accessible web pages throughout society. Many educational institutions have felt obliged to provide accessible web content under Section 504 of the Rehabilitation Act, the ADA, or relevant state laws. They have embraced universal design for web accessibility as institution-wide policy.

In addition, web page modifications made for individuals with disabilities often benefit all users. One excellent example is the addition of alternative text, or "alt tags," for graphics and other images on a web page. Alt tags give individuals who are blind or vision-impaired a text description of graphics that can be converted to audio by their screen reader technology. Without alt tags, images and whole pages may be useless to a student, since screen readers are unable to interpret the graphical content of an image. If images are used as links, omission of alt tags also may affect a student's ability to navigate through a site and to use links to other sites.

Having text-based content is also important for nondisabled users. For instance, some individuals with slower internet connections frequently turn off graphics for faster loading of pages. They will miss graphics content unless it is also available in an alternative text format. Most web page content is being delivered to cell phones and other mobile computing devices. Screens on these devices are generally small, making it difficult or impossible to view graphics-intensive sites. Advances in audio and other technology may also increase the importance of text alternatives to graphics. For instance, mobile computer users may choose to have web content read to them while commuting, walking, or exercising. Alternative text formats make that possible.

Much of the technology for making websites more accessible has been available for years, and more is being developed. The main requirements for accessible web pages in academia are simple: teachers and administrators who are aware of the need for accessible websites and who are committed to meeting that need. Educators should communicate that commitment to the web page author and developer. Many web-authoring tools provide automated ways of

inserting accessible features into pages. Other tools do not, and the web developer may have to add additional coding — such as specific hypertext markup language (HTML) instructions by hand. Specific instructions to design a web page for accessibility may be helpful in encouraging web authors to devote adequate time to this process. This extra effort may not be made unless the web author receives specific instructions to design a page for accessibility.

Free online accessibility validation tools can help determine whether existing web pages, as well as newly designed pages, are accessible to students with disabilities. They include the World Wide Web Consortium HTML Validation Service, the WAVE Accessibility Evaluation Tool, and the WebAIM Accessible Website Certification.[23-25] Commercial validation tools also are available and can be located by searching the internet.

4.5.2 Accessibility Guidelines

Guidelines for developing accessible web pages are available on the internet. The definitive guidelines were developed by the World Wide Web Consortium (W3C), which establishes protocols and standards for the web.[26,27] W3C's Web Content Accessibility Guidelines (WCAG) have several versions, the most recent of which is version 2.1, and different levels A–AAA. It is commonly accepted that if an institution meets the standards set forth in WCAG 2.0 AA, the website is adequately accessible. W3C has developed logos that can be inserted into web pages to indicate the level of compliance. The Architectural and Transportation Barriers Compliance Board, widely known as the Access Board, used the WCAG standards in developing its Section 508 standards.[28] The Access Board is an independent federal agency devoted to increasing access for individuals with disabilities.

The U.S. Department of Education’s Office for Civil Rights has developed a series of open videos that discuss digital media accessibility, the associated laws and standards, and methods to decrease barriers.[29] In considering standards, educational institutions should do the following:

- Identify all applicable laws and regulations that relate to accessible web content.

- Use the WCAG standards as guidelines for developing standards that fit the needs of their specific institution. At a minimum, institutional standards should meet the WCAG 2.0 AA criteria.

- Review standards set by educational institutions similar in terms of mission, size, and other characteristics.

- Avoid unilateral decisions. Get input from a broad range of individuals, including administrators, web developers, faculty, students, and especially individuals with disabilities. Develop a system to identify and maintain contact with individuals who place content on the institution's site. Especially important is a registration process that allows individuals to be contacted by email.

Accessibility of many web pages can be greatly improved by simply inserting a link to a text-only version at the very top of a page, where a screen reader will encounterit immediately. At the very least, it is essential to provide text alternatives to graphics. WebAIM has several articles that describe incremental changes to websites that have a significant impact on accessibility.[30] Alternative presentations of tabular information can be introduced with relatively little effort. For example, the table could be presented in an alternative design so that the headers can be read along with the data in this fashion: "Course number, 300: Department, Inst; Time, two o'clock; Days, M W F; Credits, three point oh; Classroom, DFB378E; Instructor, Smith." Web developers can find instructions for designing tables that can be read in this way at the WebAIM website.[31]

4.6 Electronic Resources for Teaching

The use of technology in teaching has increased in the form of online instruction, asynchronous content delivery, and in-class enhancement. Between 2020 and 2022, the advent of COVID-19 protocols has resulted in most college courses and many high school courses requiring an online component. Careful and considered use of technology can greatly enhance a course and student’s access to resources; however, overuse of non-accessible resources has the potential to marginalize students with disabilities. As with any mode of teaching, it is important for the instructor to have conversations with the students to ensure that the materials and delivery are accessible and meeting the needs of the students.

In particular, one major issue with online classes is the isolation that students feel, even during small group work, and this could be more of an issue for a student with a disability — especially if the student is quieter, self-conscious, or unwilling to self-advocate in front of an audience. For example, for online courses, the student may be viewing other students, perhaps a signer, and the instructor on a screen that might be at a less than optimal distance and angle. The sounds from some speakers might be very low or high, causing major changes in the volume — a difficulty for all students, but especially for those that have a hearing related disability. If a student’s only opportunity to quietly ask for clarification or help is through the chat function, they may get left behind in the discussion unless the chat function is being used effectively, meaning that the instructor or another person monitors the chat and brings issues forward to the whole class. If the clarifications come back only through the chat, the added time managing the chat conversation can cause students with disabilities to fall behind on the discussion as well. Hands-on work becomes even more difficult for all students, and it can be

difficult for the instructor to detect any issues. Addressing those issues can be disruptive to the remote class, whereas a quiet conversation could have been useful for in-person classes.

While there are negatives to online classes, there can also be positives for students with disabilities. Having more material (written, audio, or video) can be a boon to student learning, especially if those resources are made available in accessible formats. The ability to go through the materials multiple times in multiple formats can help all learners. For some students, having online classes can lessen challenges of getting to and from class, lessen the worry associated with possible illnesses circulating in the classroom, and decrease social anxiety issues. Also, the ability to access signers, interpreters, and student assistants from non-local sources can help those students in less populated areas.

There is still much to be learned about the best methods to include electronic resources in both in-person and online courses. The *Journal of Chemical Education* has devoted an issue to teaching during the COVID-19 pandemic and has another one planned for 2022 as a follow-up.[32]

4.6.1 Learning Management Systems (LMS)

A Learning Management System (LMS) is an online platform for housing and delivering course content. It is typical for a campus to adopt a single LMS to be used across the curriculum, which can be linked to a school's registration. Popular LMS include Moodle, Canvas, Blackboard, and Docebo. Each LMS has built-in accessibility standards which can be found at their dedicated accessibility sites.

Moodle: https://docs.moodle.org/310/en/Accessibility

Blackboard (now part of Anthology): https://www.anthology.com/trust-center/accessibility

Canvas: https://community.canvaslms.com/t5/Canvas-Basics-Guide/What-are-the-Canvas-accessibility-standards/ta-p/1564

Docebo: https://www.docebo.com/products/learn-lms/features/accessibility/

Within the LMS, an instructor can link to external resources, upload files, create quizzes, and send announcements to classes. All of the popular LMSs require tags or text description for uploaded images, so preparing an accurate description of any image files in advance is good practice. It is recommended that editing within the LMS be done in plain text, in order to take advantage of the inbuilt accessibility features, such as standard fonts and scalable text sizes. Common symbols used in chemistry can be entered as special symbols, which can be found under the insert menu in the text editor.

There are two common file types for large text files: Word (.doc, .docx, .odt) and Portable Document File (.pdf). When uploading files to the LMS, Word files are preferable to Portable Document files for accessibility, since the text in a Word file can be resized or reformatted easily by the student.

4.6.2 Creating Content for Asynchronous Delivery

The pedagogy of time-shifting, or “flipping”, a class involves students interacting with the source material before class, usually in the form of pre-recorded lectures or readings. These lectures can be hosted on a platform such as YouTube or Vimeo, or stored in shareable cloud storage, and then streamed through the LMS.

The creation of asynchronous content in this fashion has some advantages for all students as well as students with disabilities. Asynchronous content gives the student an opportunity to pause, rewind, or replay. With intentional design, content can be created with inbuilt accessibility features that take into account most common class accommodations.

One of the most common methods of content creation is to record a narration over a slide deck. When preparing a slide set for narration, it is important to leave a blank space at the bottom of each slide for closed captions. If you include images in your slides, provide described versions of the image and avoid any animations or transitions that are not able to be interpreted by a screen reader. Prepare a script for the narration in advance. This script can be provided as a transcript and can also be uploaded to video hosting sites in order to avoid misinterpretation of similar-sounding words by automatic captioning (such as speech to text services). If your slides include mathematical functions, write them on a single line for them to be read by screen readers.

Both Vimeo and YouTube offer captioning. A video uploaded to either site will have speech to text generated within a few hours of initial rendering. If you use the automatic captions, there will be no punctuation or capitalization; however, both sites allow the automatic captions to be edited. Both sites allow for the upload of a text file, which can be matched to the voice patterns. This is preferable to automatic captions as the text file can contain punctuation, unusual capitalization (such as chemical formulas), technical vocabulary associated with chemistry, and an unambiguous word list.

4.6.3 Remote Classes and Lecture Recording

A remote class is the situation where students are present at the same time but are attending class from their own devices in individual locations, using conference software such as Zoom, Microsoft Teams, WebEx, or Google Meet. Sometimes creative solutions need to be designed to enable full participation from all participants. For example, during live meetings or lectures, Teams currently moves items around anytime someone shares their screen, causing difficulties in finding interpreters on the viewing screen. A solution that has worked at one location is to use "dual platforms" by running two platforms — one Zoom/one Teams, etc. One platform is used for the sign language interpreter, if the student desires ASL, and the second platform is used for the lecture material itself. A few of the platforms also allow “pinning” of a person to a particular location on the screen which allows students to affix the interpreter to one location.

The quality of a teacher or presenter’s audio is dependent on the speed of the internet connection, and so a wired, direct Ethernet connection should be used if possible. Both Zoom and Google Meet can generate speech to text captions; however, the accuracy of these is highly dependent on a lot of factors such as accent, the vocabulary used, the quality of the speech to text program, the clarity and pace of the presenter’s voice, and the specific

vocabulary — the more technical the material, the more likely that automatic captions will be completely unusable. Also, some of the services require a professional license for the speech to text service. It can be beneficial for organizations to require the speech to text option to be the default in the administrator setting to aid in accessibility in all meetings. A remote session can also be recorded, and if that recording is hosted on a hosting platform such as the ones discussed in Section 4.5.2 then automatic captions will be generated. As noted earlier, these captions should be edited before posting for the students to ensure better accuracy.

A common component of a remote class is to share the presenter's screen while discussing material. Text on slides that are presented will not be readable by a screen reader, so make the presentation available to students outside of the remote class. It is also often impossible (depending on the platform used) for the user to resize the material when in shared mode which can be an issue for students with low vision or learning disabilities.

One method of improving accessibility of a remote class is to take advantage of the available chat system. Text copied and pasted into the chat system will be read by a screen reader. Chat also allows students with speech and hearing disabilities to be able to access material on an even footing with peers. It is important for the instructor to be aware, though, that these multiple streams of input can require more time for a student to process. So, pacing of the materials is critical.

For students with social anxieties or paranoia, remote classes can be a mixed blessing. The ability to turn off the camera and be more "anonymous" can allow a student to feel more comfortable in the learning situation. However, it can also isolate students and encourage them to stay silent instead of asking questions. Again, the chat system can help with some of this. It can often be easier to type in a question or response instead of saying something verbally. In addition, careful use of voting and emojis in the conferencing software can help the student and instructor communicate more indirectly. However, it can be a challenge to engage students with the material and help them feel comfortable in the remote setting. Discussions with the students can help guide the effectiveness of different methods.

Some schools are using a system where a student can join a class remotely while the instructor is in a classroom at the same time as students joining in person. This model is called hybrid flexible, or hyflex. A hyflex course can lead to a lack of accessibility, particularly if an instructor is using a stationary board in the classroom, where the students joining remotely in the hyflex model will be observing the board from a smaller connection. Pasting the content of a board into chat or, if the instructor is using a smart board or Elmo device, saving an image of the board, annotating that image, and making it available to students can improve the accessibility of a hyflex class. How to manage these classes well for students with disabilities is still an open question.

4.7 References

1. NC State University, College of Design. *The Center for Universal Design.* https://design.ncsu.edu/research/center-for-universal-design/ (accessed 2023-07-21)

2. Mace, R.L.; Hardie, G.J.; Place, J.P. *Accessible Environments: toward Universal Design.* Center for Universal Design, North Carolina State University: Raleigh, NC, 1993.

3. Cast. *About Universal Design for Learning*. https://www.cast.org/impact/universal-design-for-learning-udl#.Xn4Vqoj7QdU (accessed 2023-07-21)

4. Texthelp. *7 Universal Design for Learning Examples and Strategies for the Classroom*. https://www.texthelp.com/resources/blog/7-ways-to-introduce-udl-into-your-classroom/ (accessed 2023-07-21)

5. Disabilities, Opportunities, Internetworking, and Technology. *Making Science Labs Accessible to Students with Disabilities*. https://www.washington.edu/doit/making-science-labs-accessible-students-disabilities (accessed 2023-07-21)

6. Banerjee, M. *Universal Design in Chemistry for Neorodivergent Learners*; Landmark College. http://oxide.jhu.edu/2/NDEW_2019/OXIDE_Banerjee_4-8-2019.pdf (accessed 2023-07-21)

7. Kennepohl, D. Laboratory activities to support online chemistry courses: a literature review. *Can. J. Chem.* **2021**, *99* (11), 851–859. DOI: 10.1139/cjc-2020-0506 (accessed 2023-07-21)

8. Disabilities, Opportunities, Internetworking, and Technology (DO-IT). *Search results for "chemistry lab"*. https://www.washington.edu/doit/search/node/chemistry%20lab (accessed 2023-07-21)

9. Tallman, D. E. pH Titration Apparatus for the Blind Student. *J. Chem. Educ.* **1978**, *55* (9), 605–606. DOI: 10.1021/ed055p605 (accessed 2023-07-21)

10. Code of Federal Regulations. *Part 1191, ADA Standards for Accessible Design*, 56 FR 35408, 36 CFR. https://www.ecfr.gov/current/title-36/chapter-XI/part-1191 (accessed 2023-07-21)

11. U.S. Access Board. *Advancing Full Access and Inclusion for All*. https://www.access-board.gov/ (accessed 2023-07-21)

12. American National Standards Institute. *ANSI Z358.1-2014: Emergency Eyewash & Shower Standard*. https://blog.ansi.org/2018/07/emergency-eyewash-station-shower-ansi-z358-1/#gref (accessed 2023-07-21)

13. Perry, J.; Baum, J. Accessibility in the Laboratory. In *Assessing the Laboratory Environment*; ACS Symposium Series; American Chemical Society: Washington, DC, 2018; Vol. 1272, pp 25–60. DOI: 10.1021/bk-2018-1272.ch003 (accessed 2023-07-21)

14. Blumenkopf, T. A.; Swanson, A. B.; Larsen, R. P. Mobility-Handicapped Individuals in the College Chemistry Curriculum: Students, Teachers and Researchers. *J. Chem. Educ.* **1981**, *58* (3), 213–221. DOI: 10.1021/ed058p213 (accessed 2023-07-21)

15. Woods. M.; Blumenkopf, T. A. *Working Chemists with Disabilities: Expanding Opportunities in Science*; American Chemical Society: Washington, DC, 1996.

16. Gerig, J. T.; Nieman, R. A.; Popplewell, R. F. Changing Samples in Superconducting Magnets from a Seated Position. *J. Magn. Reson.* **1983**, *53*, 129–130 (accessed 2023-07-21)

17. National Science Foundation. *Dear Colleague Letter: Persons with Disabilities – STEM Engagement and Access (PWD-SEA)*. https://www.nsf.gov/pubs/2021/nsf21110/nsf21110.jsp (accessed 2023-07-21)

18. National Institute of Health. *Research Supplements*. https://www.niaid.nih.gov/grants-contracts/research-supplements (accessed 2023-07-21)

19. National Center for Science and Engineering Statistics*. Data Tables*. https://ncses.nsf.gov/pubs/nsf19304/data (accessed 2023-07-21)

20. Pew Research Center. *Americans with disabilities less likely than those without to own some digital devices*. https://www.pewresearch.org/short-reads/2021/09/10/americans-with-disabilities-less-likely-than-those-without-to-own-some-digital-devices/(accessed 2023-07-21)

21. WebAIM. *Accessibility in mind*. https://webaim.org/ (accessed 2023-07-21)

22. GSA Section508.gov. *IT Accessibility Laws and Policies*. https://www.section508.gov/manage/laws-and-policies/ (accessed 2023-07-21)

23. W3C. *Markup Validation Service*. https://validator.w3.org (accessed 2023-07-21)

24. WAVE. *WAVE Web Accessibility Evaluation Tools*. https://wave.webaim.org (accessed 2023-07-21)

25. WebAIM. *Accessible Website Certification*. https://webaim.org/services/certification/ (accessed 2023-07-21)

26. *World Wide Web Consortium, W3C, Home Page*. https://www.w3.org/ (accessed 2023-07-21)

27. W3C. *W3C Accessibility Guidelines (WCAG) 3.0*. https://www.w3.org/TR/wcag-3.0/ (accessed 2023-07-21)

28. U.S. Access Board. *Section 508 Best Practices: New Approaches to Web Accessibility Requirements under WCAG3*. https://www.access-board.gov/webinars/2021/07/27/new-approaches-to-web-accessibility-requirements-under-wcag3/ (accessed 2023-07-21)

29. Americans with Disabilities Act National Network. *OCR Video Series*.

30. WebAIM. *Articles*. https://webaim.org/articles (accessed 2023-07-21)

31. WebAIM. *Creating Accessible Tables*. https://webaim.org/techniques/tables/ (accessed 2023-07-21)

32. Journal of Chemical Education Special Issue: *J. Chem. Educ.* **2020**, *97* (9), 2375–3470.

Chapter 5: Service Animals

Patricia Ann Redden
Chemistry Department, Saint Peter's University,
2641 Kennedy Blvd., Jersey City, NJ 07306

Email: predden@saintpeters.edu

Chapter 5 Contents

5.1 Definition of a Service Animal
5.2 Access Rights
5.3 Considerations in the Classroom
5.4 Considerations in the Laboratory
5.5 Conclusion
5.6 References

As the number of students using service dogs increases, it is very likely that, at some point in the future, you will have a student who plans to bring a service dog into the classroom and the laboratory. The Americans with Disabilities Act (ADA) requires that public schools (K–12) and postsecondary institutions allow students to bring service dogs into any part of the facility that is open to the public or to students, which includes classrooms and laboratories as well as public spaces. However, the presence of the dog, particularly in the laboratory, raises specific considerations that are the focus of this chapter.

5.1 Definition of a Service Animal

The Americans with Disabilities Act (ADA) defines service animals as dogs that are individually trained to do work or perform tasks for people with disabilities; the tasks must be specifically related to the person's disability. The individual may have a physical, sensory, psychiatric, intellectual, or other mental disability. In some cases, miniature horses may qualify as service animals, although their access rights may be more limited than those of dogs.[1] For the rest of this chapter, the service animal will be assumed to be a dog.

The tasks that a service dog may carry out are quite varied.[2] Most people are familiar with guide dogs for individuals with severe visual impairments (often incorrectly called Seeing Eye dogs, which applies only to dogs trained by the Seeing Eye, Inc.). Service dogs for individuals in wheelchairs are almost as well known. Service dogs for an individual with a mobility impairment may perform tasks such as helping pull a wheelchair, helping with balance, opening and closing doors and drawers, picking items off the floor, or carrying items. Figure 1 shows a service dog pushing a button to open an automatic door. Less familiar are hearing dogs for individuals with a severe hearing loss, alerting their partners to emergency sirens and alarms as well as doorbells, phones, timers, and other ordinary sounds. Seizure alert dogs respond to subtle body signals indicating that a seizure is imminent, and they may warn of the seizure in advance, stand guard over the partner, or seek help. Diabetic alert dogs respond to

changes in an individual's blood sugar, through either scent or behavior changes, and warn the partner to take steps to adjust the blood sugar level. You may also encounter service dogs for individuals with autism, psychiatric needs, or post-traumatic stress disorder (PTSD). These dogs may perform tasks such as stopping repetitive behavior, protecting an individual in a stressful situation, providing safety checks of an area, or reminding their partner to take medications. It is even possible, although somewhat unusual, for an individual to have more than one service dog, each trained to perform different tasks.[3]

Figure 2: Medical alert and guide dogs. (Google Images)

Service dogs may be trained by an organization or by an individual, intentionally bred by the organization or rescued from a shelter. They may wear a vest or have an identification card, but there is no requirement or even recommendation under the ADA for either. A college or university may offer voluntary registration of the service dog but may not require such registration. They may be of any breed or mixed breeds, and size can range from a chihuahua to an Irish wolfhound. In Figure 2, a medical alert service dog wears a pack holding necessary supplies while the guide dog wears a harness for its blind partner, and only the guide dog wears a service dog patch. The partner may have an obvious disability or an invisible one. In some cases, the partner may be accompanied by an aide who acts as the handler for the service dog. Regardless of the situation, the ADA does not require the dog's partner to show identification for the dog as a service dog or to prove that the dog is certified or trained as a service dog. If the need for the service dog is not obvious, only two questions can be asked: (1) Is the animal required because of a disability? (2) What work or task has the animal been trained to perform? The partner cannot be asked about the nature of the disability or to demonstrate the task the animal performs.[1]

To complicate the issue, service dogs are often confused with emotional support dogs and therapy dogs. Emotional support dogs work with an individual to relieve stress, depression, or anxiety, keeping the partner calm simply by their presence, but they don't perform a specific physical task. Therapy dogs typically have a similar role in a group or clinical setting. A growing problem is the misidentification of pets or emotional support dogs as service dogs; legislation is currently either passed or being considered by individual states to address this issue.

5.2 Access Rights

Under Title II and Title III of the ADA, service dogs are allowed to accompany their partners into any area where the public is allowed, which includes classrooms, laboratories, dining facilities, housing, and other sections of public educational institutions. Religious institutions are not included under the ADA requirements unless they accept federal funds. Service dogs may only be excluded where their presence would present a direct threat to the health and

safety of others, if they are not under control by the handler, or if they are not housebroken. Note that it is the human partner who has the right to bring the dog; the dog itself does not have access rights.[4]

While the service dog is with its partner, whether or not it is wearing an identifying vest, it is assumed to be working. A working service dog should not be distracted in any way; that includes petting, giving treats or food, bringing another dog or a child over to “say hello,” and even talking directly to the dog. If the dog is distracted, even momentarily, it cannot focus on carrying out the tasks on which the partner depends. This could lead to a safety issue for the partner. While it is working, the service dog should be treated like any other piece of adaptive equipment such as a wheelchair or white cane. No matter how much you love dogs and how adorable it is, you must ignore it totally.

Emotional support dogs (and other animals) and therapy dogs are not allowed access to public areas, including both classrooms and laboratories, unless granted by the individual institution. Emotional support animals may, however, qualify as a “reasonable accommodation” under the Fair Housing Act (FHA) and so may be allowed to live in university housing.[5]

An additional category is dogs in training to become service dogs. An increasing number of students, either as individuals or through college clubs, raise puppies for organizations that provide trained service dogs to individuals with disabilities. The puppy raisers are responsible for doing basic training for the puppy, which includes socializing it to a variety of experiences; the actual disability-related training will be done at a later time by professional trainers. Another possibility is that an individual with a disability may be self-training either a puppy or an older dog to meet that individual’s specific needs, with or without the help of a professional trainer. In some states trainers and puppy raisers are legally given the same access rights as a service dog team, while in other states access to a facility must be voluntarily given by consent of the property owner. In either case, serious consideration should be given to determine whether it is in the best interest of the puppy, the puppy raiser, or other individuals to allow its presence in a chemistry laboratory, particularly if the puppy is not fully trained and will require more attention from the puppy raiser than a trained service dog would. In fact, at least one national organization that trains service dogs forbids its puppy raisers to bring a puppy into a laboratory environment. There is no problem with allowing a well-behaved service puppy in a classroom.

It is advisable for each institution to have a written policy for service dogs, emotional support animals, and service dogs in training. The policy should identify areas where service dogs are not normally permitted for ADA-compliant reasons, although access to those areas might be allowed on a case-by-case basis. Off-limits locations, acceptable under the ADA, are usually areas where there is a health or safety concern for others or where the presence of the dog would fundamentally alter the nature of the services offered.[4] Examples include sterile areas or machine shops. Procedures should be given for exceptions from the prohibition. A comprehensive policy should also include emergency procedures for evacuation or if the partner or dog is injured, particularly if such an emergency requires separation of the dog and partner.

5.3 Considerations in the Classroom

A service dog must be under the control of the partner, which usually means on a leash and in close proximity to the partner. In some cases, the partner may not be physically able to hold a leash or the leash may interfere with the dog's task; if this is the case, some other means of control, such as voice control or signals, is acceptable. If the service dog is not housebroken, behaves in an unacceptable way such as uncontrolled barking or jumping, or is not under the control of the partner, it may be removed from the area.[4]

The presence of other students or instructors who have an allergy to or a fear of dogs is not sufficient to deny the partner's right to bring the dog into the classroom or laboratory. It may be possible to assign the affected individual — not the student with the disability and the service dog — to another section of the course. If not, the appropriate response would be to provide space between the dog and the other individual.

Service dogs are trained to fit into relatively small areas and be inconspicuous. In the classroom or lecture hall, this usually means that the dog lies at the student's feet or under the desk. A large service dog may, of course, require more room. It is important to remember that the individual with the dog must not receive more or less favorable treatment than others, nor can the pair be isolated. Unless all students are assigned seats, for example, the student with the service dog should have the same free choice of seating. It is the institution's responsibility to accommodate both the student with the service dog and individuals with allergies or fear issues.

5.4 Considerations in the Laboratory

In the laboratory, the presence of a service dog requires discussion with the dog's partner. The student's need for the service dog is paramount and its presence is allowed by the ADA, but the discussion should also address the accommodations needed to ensure the safety of the human partner, the service dog, and the other students in the laboratory. Considerations include the physical setup of the laboratory, the chemicals used in the area, the operations carried out, and whether the presence of the dog would potentially affect the work. As a result, each situation is unique, and the goal is to find the best way to safely meet the needs of the student without violating the student's rights under the ADA.

It may be useful to apply the RAMP[6] protocol designed to increase laboratory safety. RAMP is an acronym developed by David Finster, Ph.D., and Robert Hill, Jr, Ph.D., to stand for *Recognize* the hazards, *Assess* the risk of the hazards, *Minimize* the risk of the hazards, and *Prepare* for emergencies from uncontrolled hazards. A *hazard* is a source of potential damage or harm to an individual's health or life; by extension here we will also consider hazards to the service dog. *Risk* is the probability of an individual (or service dog) being harmed if exposed to a hazard. The terms hazard and risk are not to be taken as a reason to deny the dog access, but as a basis for determining the accommodations needed to create a safe environment for the student, the service dog, and others in the laboratory.

5.4.1 Recognize the Hazards

The safety of the service dog will be a matter of prime concern to its partner. During laboratory sessions where chemicals are used, dangerous situations for the dog may include: solids spilled on a balance pan or a bench, then possibly blown or swept off to the floor; liquids

spilled or dripped onto a bench and then to the laboratory floor; glassware broken and small pieces or slivers left on the floor; heavier-than-air vapors traveling to, and pooling on, the floor if volatile chemicals are used on a bench, rather than in a fume hood. On the other hand, an instrumental laboratory or an individual research laboratory usually has minimal exposure to chemicals and therefore less protection is needed.

The laboratory environment should be reviewed for potential hazards for a dog. The presence of waste containers, vacuum pumps, or solvent drums on the floor or on low shelves could create a safety issue for a dog if not removed. Traffic patterns, the number of people working in the laboratory, the location of emergency exits, safety showers, and eyewash units should also be considered when selecting a safe location for the student and dog.

The instructor needs to consider the impact of the dog's presence on the safety of other students in the laboratory. The American Chemical Society publication, *Safety in Academic Chemistry Laboratories* (commonly referred to as SACL), states that the aisles and safety equipment in a laboratory should be free of obstructions, including stools, backpacks, and open drawers or cabinet doors.[7] A service dog lying in an aisle is also an obstruction and is well below eye level; additionally, even though the service dog is trained to remain in one position and location for an extended period of time, the dog's legs and tail may move and protrude farther into the aisle. A passing student might trip over the dog or its mat, so a safe location in a low-traveled area must be found for the dog.

If the service dog is trained to alert its partner to a sound, medical situation, or similar situation needing a response or action, the method in which the dog delivers the alert may startle the student and others in the laboratory while engaged in a chemical operation. The instructor should be aware of the alert method and the response to the alert.

Finally, consideration must be taken of the type of work being performed in a laboratory that houses living species. Dogs could bring in organisms that would interact with the study species or could themselves be exposed to organisms being studied in the laboratory; if live animals are being studied or used as test subjects, the dog's presence may change their behavior, particularly if it is perceived as a predator by the test animal.

5.4.2 Assess and Minimize the Risks of the Hazards[8-12]

In order to identify concerns about bringing a dog into the laboratory environment and make the student aware of them, it is recommended that a meeting be held including the dog's partner, the laboratory instructor and/or department chair, any institutional personnel involved in laboratory safety, and the institutional representative(s) responsible for meeting the needs of students with disabilities. During that meeting, discussion should include the services the dog provides to its partner, how those services are be needed and delivered in the particular laboratory setting, possible alternate ways of providing those services, and how the safety of the dog and the humans could be maximized. This discussion should be ongoing through the semester if the situation changes, and it should be repeated for new laboratory courses or settings.

5.4.2a <u>Tasks</u>: Primary considerations include the tasks the service dog provides for its partner, whether those tasks can or should be carried out by the dog in a laboratory setting, and if there are alternative accommodations acceptable to the student. Some examples of tasks that a service dog may provide in everyday life that could affect the risk in the laboratory include:

- A student in a wheelchair may normally depend on a dog to pull the wheelchair, pick up dropped items on command, or carry materials such as packages. In a laboratory setting, it is obviously potentially dangerous to request the dog to pick up any materials from the floor where spilled chemicals or broken slivers of glass may be found, nor would it be safe for the dog to carry chemicals or glassware, even in a carrier.

- A student with a severe hearing loss depends on the service dog to alert its partner to sounds such as telephones, alarms, timers, or someone seeking the partner's attention. The dog is trained on individual sounds in order to respond properly, and it must be able to ignore everyday background noises (e.g., television, traffic) and to respond appropriately to others (e.g., bringing the partner to the door when the doorbell rings or alerting to a smoke detector alarm). Laboratory noises range from the constant background hum of fume hood exhausts to intermittent sounds like a compressor or vacuum pump kicking in, and these sounds will initially be strange to the dog and require acclimatization to allow the dog to distinguish between the normal noises and those sounds which require a response or alert. An additional concern may be the method the dog uses to alert the partner, which could impact others in the lab.

- A guide dog for a student with a visual impairment is helpful in safely bringing its partner from one location to another. The dog will have to become familiar with the laboratory layout, including items on or near the floor, exits, and traffic patterns. While the student is working at the laboratory bench, the dog's help may be unnecessary. Help is usually only required when going from the door to the laboratory station and back, perhaps moving to a balance or dispensing area, or in an emergency situation.

- A service dog trained to alert and/or respond to seizures, a diabetic incident, a PTSD attack, or similar medical condition is needed at all times by its partner and usually cannot be adequately replaced by a human or even a medical device. This type of service dog recognizes the need for its help before an incident occurs and takes measures to prevent or ameliorate the incident; a human would only see the need for help after the fact. Some service dogs performing these functions are small and may be carried in a pouch or in the partner's arm; other dogs are larger and will remain on the floor. The methods by which the dog alerts its partner and performs the mitigating task may create a hazard if the partner or nearby students are handling chemicals or equipment.

In many cases, the tasks normally performed by the service dog can be carried out by a laboratory partner or an aide provided by the Office of Disability Services. For instance, that individual can pick up dropped items or transport chemicals or equipment to and from the lab bench. A human may be able to more easily discriminate the sounds that require a response compared to the normal ambient sound in the laboratory. A student with a visual impairment may need guidance to different locations in the laboratory, but again that guidance could be supplied by a laboratory partner or aide.

5.4.2b <u>Alerting the Partner:</u> The way in which a medical alert dog interacts with its partner might be by barking or nudging. A psychiatric or PTSD service dog might take physical action to stop or prevent an incident while a hearing dog may be trained to nudge or paw its partner. These methods could startle the partner and possibly others in the area, creating a hazard if the student is carrying or using chemicals. Other dogs may be trained to sit, lie down, or hold in the mouth a ribbon or a short rod attached to its collar or hanging nearby (known as a bringsel alert) to get its partner's attention. These methods also have their own hazards in the laboratory setting, since a student intent on a laboratory task may overlook the silent, non-physical alert and the ribbon or rod (which must be hanging outside of the protective coat on the dog) may be exposed to spilled chemicals on the floor. The alert method would have been taught by the dog's trainer or the organization from which the dog was received. It is unrealistic to expect that the alert method can or should be changed in a short time for a single laboratory course. However, sharing information with the instructor and those in the area about the method of alert and the way in which they should respond will help to minimize the safety concerns while maximizing the alert.

5.4.2c <u>Safety inside the Laboratory:</u> Service dogs, whether trained by an organization or by the human partner, are expected to be under the control of their partner, quiet, and well-behaved at all times. In the laboratory, they are also expected to remain where they are placed for the duration of the laboratory, which might be several hours, without becoming restless or moving unless performing a disability-related task. They must also be willing to wear appropriate personal protective equipment. If the dog is trained to pick up items from the floor, that should only be done on command, not automatically when something is dropped. In case of an emergency situation, the dog should be able to be handled by security or laboratory personnel.

Figure 3: Service dog in full personal protective equipment (courtesy of Joey Ramp)

After the discussion, if the student decides to bring the dog into the laboratory, the group should consider the best location and appropriate protective equipment for the dog and emergency procedures to be followed in case of an accident or a need to evacuate the student and laboratory participants. Depending on the physical layout of the laboratory, safe locations for the dog might include a wheelchair recess under a laboratory bench, under a nearby balance table, or possibly against a wall or in a corner near the student's bench. A tether or crate might be an option in some circumstances. If the dog is a small medical alert dog carried in a pouch on the student's body, it will be more exposed to chemicals and more extensive protection should be supplied.

5.4.2d Protective Equipment: Given the wide variety in the chemicals and operations in academic laboratories, a reasonable guideline for personal protective equipment for the service dog is to match that required for students. Safety in Academic Chemistry Laboratories (SACL) identifies acceptable personal protective equipment for students in a chemistry laboratory: clothing that minimizes the amount of exposed skin, nonflammable and nonporous aprons or laboratory coats, shoes with leather or polymeric leather substitutes that completely cover the feet and toes, and goggles rated for chemical splash protection.[7] A service dog in the laboratory merits equal protection, particularly since it is more imperiled by materials dripping off the bench or spilled on the floor, but there are currently no standards for its protective equipment. Figure 3 shows a service dog wearing full personal protective equipment. Water-resistant booties with rubber or other sturdy soles will protect the dog's feet from chemicals or glass slivers on the floor and can be purchased from many suppliers, in a size to fit the dog's feet. Goggles should provide splash and impact protection; Doggles and Rex Spex are good for this purpose, and even human splash goggles may fit some dogs. A mat with a plastic backing will protect the dog when it sits or lies down; this may be a reusable mat or even appropriately sized disposable pet pads. However, booties, goggles, and a non-permeable mat to lie on are not always adequate protection. The addition of a non-permeable full body suit or coat will protect the dog's body and fur from chemical exposure; it will also minimize the amount of hair and dander shed by the dog in the laboratory. At the time of writing this chapter, there are no commercially available dog lab coats, so the usual procedure is to make one from a cotton or Tyvek lab coat, sized to fit the dog. In this case, the upper body and sides should be fully covered, with buttons or other closures overlapping if possible under the dog's chest. Ideally the coat should be removed immediately upon leaving the laboratory and washed after each use; shampooing the dog after the laboratory period will also help protect it from chemicals that may have fallen onto its fur.

5.4.2e Safe Location outside the Laboratory: If the student decides that the dog's help can be provided in other ways and that it is in the dog's best interest not to bring it into the laboratory, the necessary accommodations for the student should be identified and implemented. A secure spot outside the laboratory would have to be identified for the dog to stay during the laboratory period. The location should be nearby, comfortable, protected, and away from passers-by; depending on the dog, it might be a crate or a small enclosed room or area. It should also be a location where the student can quickly get the dog when the laboratory period ends or in case of an emergency.

5.4.3 Prepare for Emergencies

Whether the dog is brought into the laboratory or left in a safe place, emergency procedures should be coordinated with campus safety, since an accident or medical emergency might require that the dog and partner be evacuated and possibly separated. In such cases, the dog may be stressed or protective of its partner, requiring skilled handling to avoid an undesirable escalation. Information should also be available about emergency veterinary treatment in case the dog is injured. If the dog is not in the laboratory, campus safety personnel should be aware of the partner's location in the laboratory, the dog's location, and any specific needs for the student in an evacuation or emergency.

5.5 Conclusion

In many cases, an alternative can be found that will be acceptable to the student for the tasks provided by the service dog. In other cases, there is no alternative for the dog's services that is acceptable to the student or the student prefers for other reasons to take the dog into the laboratory. The dog is a living provider of independence, and the partner may be understandably reluctant to give up that independence, even for a few hours. It must be kept in the forefront of the discussion that the dog is a legally protected accommodation for its partner, equivalent to a wheelchair; the only difference is that precautions must be taken to prevent harm to a living, sentient dog. The ADA regulations allow the dog in the laboratory, and it is the educational institution's responsibility, working with the student with the disability, to make the environment safe for all, but particularly for the student and service dog.

5.6 References

1. *ADA Requirements: Service Animals*. U.S. Department of Justice, Civil Rights Division, Disability Rights Section, February 28, 2020. https://www.ada.gov/resources/service-animals-2010-requirements/ (accessed 2023-07-21)

2. *Tasks Performed by Guide, Hearing & Service Dogs.* International Association of Assistance Dog Partners (IAADP), 2023. https://iaadp.org/membership/iaadp-minimum-training-standards-for-public-access/tasks-performed-by-guide-hearing-and-service-dogs/ (accessed 2023-07-21)

4. *Service Animals and Emotional Support Animals*. ADA National Network: Information, Guidance and Training on the Americans with Disabilities Act, Resources, 2014. https://adata.org/guide/service-animals-and-emotional-support-animals (accessed 2023-07-21)

5. *Frequently Asked Questions about Service Animals and the ADA*. U.S. Department of Justice, Civil Rights Division, Disability Rights Section, February 28, 2020. https://www.ada.gov./resources/service-animals-faqs/ (accessed 2023-07-21)

6. Carroll, J. D.; Mohlenhoff, B. S.; Kersten, C. M.; McNiel, D. E.; Binder, R. L. Laws and Ethics Related to Emotional Support Animals, *J. Am. Acad. Psychiatry Law,* **2020** *48* (4), 1–10. DOI: 10.29158/JAAPL.200047-20 (accessed 2023-07-21)

7. Hill, R.H.; Finster, D.C. *Laboratory Safety for Chemistry Students*; John Wiley & Sons, Inc.: Hoboken, NJ, 2010; pp 1–7.

8. *Safety in Academic Chemistry Laboratories*, 8th edition; American Chemical Society Committee on Chemical Safety, 2017. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf (accessed 2023-07-21)

9. Redden, P.A. Service Dogs in the Chemistry Laboratory. *J. Chem. Health Saf.* **2016**, *23* (1), 32–34. DOI: 10.1016/j.jchas.2015.05.002 (accessed 2023-07-21)

10. Redden, P.; Sweet, C. Service Dogs in the Chemistry Laboratory. In *Accessibility in the Laboratory*; Sweet, E., Gower, W. S., Hetzel, C. E., Eds.; ACS Symposium Series 1272, sponsored by the ACS Division of Chemical Health and Safety; Oxford University Press, 2018.

11. Redden, P. Service Dogs and Safety in Academic Laboratories, *J. Chem. Educ.* **2021**, *98* (1), 68–70. DOI: 10.1021/acs.jchemed.0c00073 (accessed 2023-07-21)

12. Notman, N. Let the dog in: how institutions and colleagues can help scientists who require support animals. *Nature* **2021**, *589*, 627–629. DOI: 10.1038/d41586-021-00190-0 (accessed 2023-07-21)

12. Nepomuceno, G. M.; Decker, D. M.; Shaw, J. D.; Boyes, L.; Tantillo, D. J.; Wedler, H.B. The value of safety and practicality: Recommendations for training disabled students in the sciences with a focus on blind and impaired students in chemistry laboratories, *J. Chem. Health Saf.* **2016**, *23* (1), 5–11. DOI: 10.1016/j.jchas.2015.02.003 (accessed 2023-07-21)

Chapter 6: Transitioning from High School to College

Carl Heltzel*,[1] and Laureen Summers*,[2]
[1]Associate Professor, Medical University of South Carolina, Director for Research Development and Senior Science Writer, Hollings Cancer Center, Charleston, SC 29425
[2]Project Director, Entry Point!, American Association for the Advancement of Science, Washington, DC 20002

***Email: heltzel@musc.edu**
***Email: lsummers@aaas.org**

Chapter 6 Contents

6.1 Introduction
6.2 The Journey to a Career in Chemistry
6.3 Acquiring Skills
6.4 Moving on to college
6.5 Internships
6.6 Awareness of and Understanding the Law
6.7 How to Be Successful: Persistence, Resilience, and Making Use of Resources
6.8 The DSS Office
6.9 The Importance of Self-Advocacy
6.10 Mentoring Students with Disabilities
6.11 College to Graduate School or Employment
6.12 Employment
6.13 References

6.1 Introduction

Transitioning from high school to college can be a difficult time for any student, and perhaps in particular for the student with a disability. It is an exciting time for students who must be prepared for this transition to greater independence and responsibility. Accessible high school out-of-lab activities, research projects, and internships are great opportunities for students to add to their skillset and prepare for college and degree completion in their chosen field. With proper support, encouragement, and good peer mentoring, any qualified student with a disability, intent on becoming a chemist, is likely to succeed.

A sense of self-awareness and confidence in the ability to persevere in a chemistry curriculum will play a part in the journey toward becoming a successful chemist contributing to an innovative STEM field.

6.2 The Journey to a Career in Chemistry

Students, teachers, counselors, and parents may not fully realize that science, mathematics, and engineering can be ideal careers for individuals with disabilities. Success in these fields often depends on problem solving. Students with disabilities have figured out how to overcome many of the barriers they often face by finding alternative solutions to a goal and develop new coping strategies. Additionally, those with non-apparent disabilities and illnesses may experience the world from different perspectives, allowing them to see new, different, or unexpected solutions. They are natural ”problem solvers.” Science should be one of the first career options considered by students with disabilities.

The relationships between students and their peers and teachers are critical to encouraging students to choose a science path. When students feel supported and valued for their skills and interests, they are more likely to persist and succeed in their chosen course of study.

During each student’s academic career, they will be faced with decisions about attending college. While students with disabilities may be just as intelligent or more so than their peers, only 50% of them enroll in college. Of those that do enroll, many are less likely to complete a degree than their nondisabled peers. The reasons for this disparity are many, and their complexity goes beyond the reach of this eBook.

Decisions that determine the practicability of a career in science often are made in the high school or middle school years. Unfortunately, some students foreclose the option of a science career early, by virtue of the middle school and high school courses they choose. Students usually must take a sequence of appropriate courses for admission to college and specific science and mathematics courses for admission into a college science major. The high school student who takes non-college-track courses will face distinct difficulties in gaining admission to college. Those who do not have proper support may take inappropriate science and mathematics courses and will face similar difficulties in gaining admission to a science degree program. Due to health, family, or financial reasons, some successful scientists did take detours after high school — into jobs, the military, or other non-college pursuits — only to enter college and excel years later. These instances, however, are relatively rare. Some successfully switched to a science major after first pursuing degrees in the liberal arts, business, or other fields. Nevertheless, it is difficult to overemphasize the importance of sparking and sustaining a student's interest in science early and encouraging a course selection that keeps career options open. More on this topic can be found in Section 6.10 of this chapter, Mentoring.

Full participation in a high school chemistry class is especially important for students who plan to continue to college, including those with no current plans to major in science. Many students change their majors and career plans after arriving on campus. A solid high school preparation in science and mathematics keeps the student's options wide open and facilitates later decisions to change majors into science fields. Many chemists with disabilities choose their science careers because of the high school chemistry courses they took. Regardless of career plans, chemistry provides excellent opportunities for students to develop problem-solving skills needed for success in college. High school chemistry provides an opportunity for the student to practice identifying specific needs and strategies for performing each new exercise in the

laboratory setting. A high school chemistry student should be strongly encouraged by faculty to learn to communicate those needs to others, especially if this has not been done in the past.

Students with disabilities must fully participate in middle school and high school science classes, including labs and other hands-on activities. Like other students, they will need to meet basic math and science requirements in college, whether they specialize in these fields or not. At the secondary level, chemistry teachers can help identify students with disabilities who are interested in participating in the classroom and laboratory and actively become involved in the development of their Individualized Education Program (IEP) or 504 plan. The plan development team should include the chemistry teacher, along with the student, special education teacher, parents, and perhaps others (see section 3 of Chapter 2 for discussion of IEPs and 504 plans).

Teachers and parents should be aware of the gaps that often occur in the academic development of students with disabilities and work to avoid them. Sometimes students with disabilities are not held to the same academic standards as their nondisabled peers, especially if their teachers have lower expectations. In contrast, students with disabilities are sometimes unfairly held to even higher standards of excellence than their peers. The most successful teachers provide appropriate accommodations for students with disabilities, in both classroom and laboratory work, and evaluate their performance fairly. Teachers should talk to students about what accommodations will be the most successful for their academic achievement. Two students with the same disability may need very different accommodations; every student with a disability is different.

Lack of access to extracurricular activities may also lead to gaps in interpersonal skills, incidental knowledge, and a lack of self-confidence.[1] Teachers should not misconstrue those as deficits in potential ability. Teachers who address student's individual needs will encourage the natural curiosity and love of learning critical for a science career. The teaching techniques described in this book and the resources listed at the end can help chemistry teachers contribute to an IEP that ensures full student participation.

All students can become more self-sufficient as they progress through middle school and high school, gradually assuming more of the responsibilities once left to their parents. Students take a greater role in selecting courses, in initiating contact with teachers to get information and resolve problems, and in identifying opportunities for participation in out-of-classroom activities and summer jobs.

Teachers, counselors, and parents should encourage students with disabilities to develop as much self-sufficiency as possible. As students make the transition from secondary school to college, they most likely have developed the coping skills for managing their disability and take greater responsibility for self-advocacy. An advocate is a supporter or defender who argues for a cause, usually on behalf of other individuals. Students with disabilities often have many innovative life skills to share with advocates and mentors. They can learn to advocate for themselves. Effective self-advocacy involves several steps, such as:

> Identify needs. Analyze the situation, consider options for addressing it, and be prepared to suggest specific solutions.

Know who to ask. Identify the specific individual or agency with authority to resolve a problem. Identify the chain of command if initial contact does not resolve the situation satisfactorily.

Know what you are talking about. Be ready to support and document statements, just as you would footnote statements in a term paper.

Communicate the request effectively. Be prepared to briefly summarize the circumstances of a situation, propose a specific solution, and state why the solution is reasonable. Consider whether the communication would be most effective if presented in person or by email or letter.

Follow up. Establish a time frame for resolution and make contact again to determine the status of the request.

Recognize the value of persistence. Continue the follow-up process — if necessary, by working up the chain of command.

Understand legal rights. Many problems result from simple misunderstandings and can be resolved courteously when all parties have better information and a clearer understanding of the circumstances. Threats of legal action should be a last resort. Have accurate information about the relevant laws before proceeding.

Understand the limitations of the system. Be aware that problems can often be resolved best on the local level: with the individual instructor, within the department, with the administration of the school. If a problem is taken through the legal system, the college term or school year may be long over before the final resolution is reached.

Students with disabilities should be familiar with the use of email, VRS, mobile phones, and other means of communication. Familiarity with search engines and effective search strategies on the internet is important for acquiring information about assistive technology, disability laws, and names of individuals with the authority to grant requests. Self-assertiveness skills are also important. Students can practice by talking with adults to articulate their own needs, contacting services like vocational rehabilitation, and attending meetings.

6.3 Acquiring Skills

Students can learn advocacy skills by getting involved in advocacy groups for their disability and with campus groups for students with disabilities. These groups may have pamphlets, web resources, and other information that a student can provide to faculty to help raise awareness of his or her capabilities. For example, a student might give to science faculty and to vocational rehabilitation counselors printed information illustrating the reasonableness of the student participating fully in chemistry and other sciences. The information might include print material about the DO-IT program,[2] the ENTRY POINT! program of internships for students with disabilities,[3] or copies of *Working Chemists with Disabilities*, available without charge from the American Chemical Society (ACS).[4] Printed material, of course, should supplement — rather

than be a substitute for — the personal rapport that students should develop with faculty and others.

Knowledge about the disability community can be very helpful. Disability-specific groups and networks are good sources of information about assistive technologies, accommodation strategies, and other topics important in the self-advocacy process. In many instances, self-advocacy may involve assistive technology, and students with disabilities should have basic knowledge of the specific assistive devices often used for their disability.

Encouraging students to engage in understanding the history of the disability civil rights movement is a really good way to dispel feelings of isolation and that they are alone in their journeys. *Crip Camp: A Disability Revolution*[5] is a great documentary, and there are many good books written by folks with various disabilities.

6.4 Moving on to college

When preparing for and choosing a college, students with disabilities consider many of the same factors that are important to all high school students, including the college's academic standing, size, degree offerings, cost, and distance from home. Students and parents should weigh the importance of these and other factors on an individual basis. Many students with disabilities need to feel ownership in planning their science journeys but have found the following tips especially helpful in making college decisions:

- Contact the state vocational rehabilitation office and college financial aid offices to check on sources of college funding and assistance with accommodations.

- Contact the Disability Support Services (DSS) office at your preferred college early and find out what resources it offers people who have a disability like yours. If the campus or office has adaptive computer labs, determine whether the equipment meets your needs.

- Visit the campus and the department of your prospective major. Do not hesitate to ask DSS or admissions personnel about possible funding for your travel to the campus. It may be available.

- While on campus, check the accessibility of buildings, transportation, classrooms, laboratories, and student housing. Note campus size and estimate the time needed to get from one class to another.

- Tune into attitudes of the individuals you meet and the campus culture. Are staff members in the admissions and DSS offices welcoming and helpful? Are faculty members willing to meet with you and discuss their courses? How do students regard you? Ask whether the DSS office provides early registration for students with disabilities. Most consider this an essential service for many students with disabilities. Then find out the exact dates and times of early registration.

- Remember that assistive technology provided by your high school may not be available after your graduation — at least not the same degree you are used to. Use your

summer transition time to locate new sources of equipment and assistance you need for college.

After high school graduation, students often benefit from using summer vacation time productively as a transition to college. Check with professors about getting titles of textbooks, copies of course syllabi, and other written material. Some students with reading disabilities can benefit from starting to read the textbooks before the semester begins. Others may benefit by working with the DSS office to convert texts and other written materials into Braille or other alternative formats. See the DO-IT website for in-depth techniques for successful transitions from high school to college.

6.5 Internships

Internships are a great way for students to experience the life of a scientist and what it is like to work in a laboratory in a professional environment. Often these experiences take place during the summer months, but occasionally they can be during the academic year.

Many companies and government agencies seek students with disabilities to participate as interns in research or lab experiments that match the student's skills and interests. These are real job experiences that can be a path to preparing for a future career. Many offer paid stipends and housing and travel assistance. For a student with a disability, internships offer them a chance to see what types of physical changes to a lab might be needed for their specific disability.

Figure 1. Student working in a NASA laboratory in an internship.

The employer has a responsibility to provide the accommodations needed to ensure student participation and success. The AAAS Entry Point! program has placed over 600 students in summer internships. Placements include opportunities at NASA, IBM, Lockheed Martin, Amgen, and university research programs (Figure 1). Approximately 85% of these students are now working scientists.

6.6 Awareness of and Understanding the Law

The accommodations and legal protections that high school students came to depend on will change after they graduate. While this is discussed in more detail in Chapter 2, a brief overview will be given here. The Individuals with Disabilities Education Act (IDEA) lays out

responsibilities and protections for students with disabilities while in high school. The U.S. Department of Education's Office for Civil Rights is responsible for enforcement of Section 504 of the Rehabilitation Act of 1973, which is focused on equal access to education programs and experiences and comes into play as students enter college. All U.S. school districts and nearly every college are subject to one or both laws. The requirements of IDEA apply to state education agencies, school districts, and other public agencies that serve IDEA-eligible children. IDEA makes it the school district's responsibility to identify a student's needs and provide appropriate services. In contrast, Section 504 provides that it is not the college's responsibility to identify students with disabilities and offer accommodations–it is the student's responsibility to self-disclose the disability, provide evidence, obtain accommodations, and monitor their effectiveness (with the help of faculty and other staff). See Figure 2 for a comparison of high school and college.

High School	College
A **teaching** environment	A **learning** environment
Student is identified by the school and is supported by parents and teachers	It's the student's responsibility to self-disclose to the Disability Services Office
Responsibility for arranging accommodations belongs to the school	Responsibility for self-advocacy and arranging accommodations belongs to the student
Teachers approach you if they believe you need assistance	Professors are usually open and helpful, but most expect you to initiate contact if you need assistance

Figure 2. Differences between high school and college.

The situation for private colleges and universities is slightly different. Institutions that do not receive federal financial assistance are not subject to Section 504 or Title II. They are, however, subject to Title III of the *Americans with Disabilities Act*, which is enforced by the U.S. Department of Justice and prohibits discrimination based on disability by private entities that are not private clubs or religious entities. Furthermore, college students are given protection of the privacy of their education records under the Family Education Rights and Privacy Act (FERPA); no parent or other party can obtain any information about a college student's grades, progress, etc. without the permission of that student.

6.7 How to Be Successful: Persistence, Resilience, and Making Use of Resources

When a college student with a disability decides to seek out and secure accommodations and services, the key to this process is persistence. Resilience, keeping a positive attitude,

flexibility—these are the traits that will enable success. Resilience and persistence are skills that can be developed, so remember, take time and easy does it.

External factors such as a supportive family, teachers, and community groups can be helpful. Students might be well advised to reach out to local ministers and community service organizations. Developing critical skills like persistence and self-advocacy and fully understanding the process for students to receive accommodations and support in college can help ensure their success.

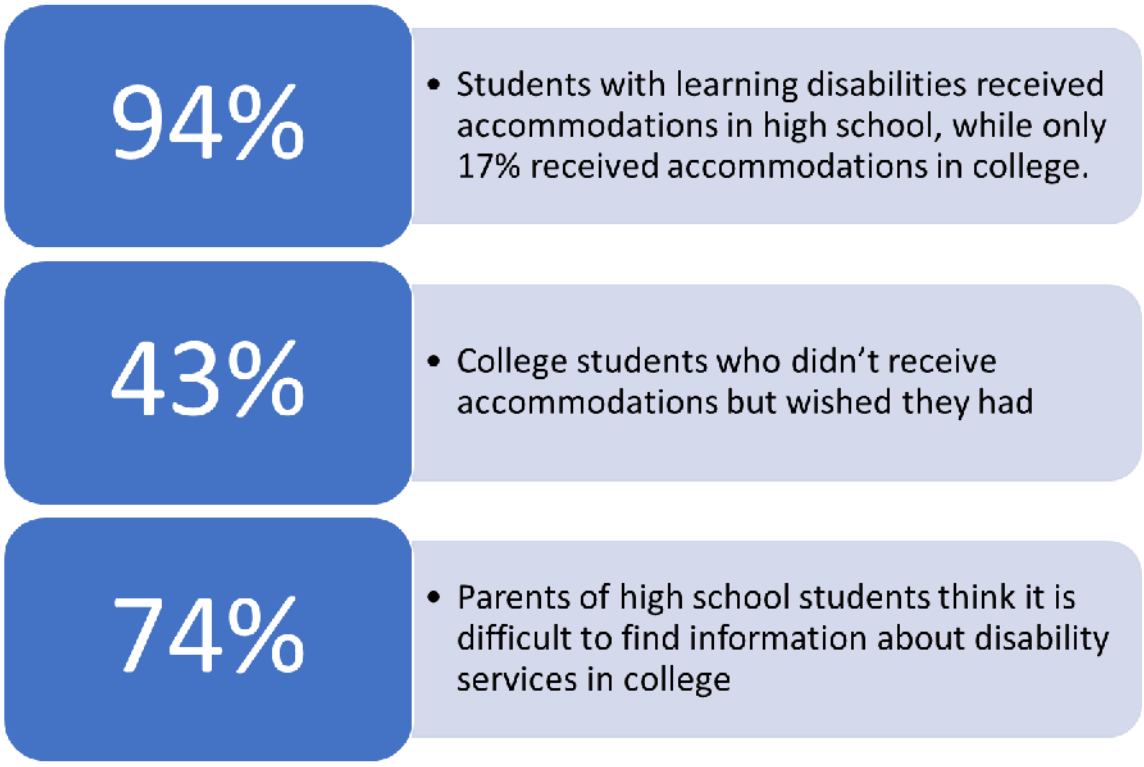

Figure 3. NCLD Issue Brief: Transition to Higher Education, 2021.

6.8 The DSS Office

Despite their growing role in advocacy, college students with a disability should make full and effective use of advocacy and other services in the Disability Support Services (DSS) office. Ideally, students will visit or contact the DSS office before the start of the academic term. From that first visit, students should establish a rapport with the DSS staff. The DSS office's central role should be to ensure that students can obtain necessary and reasonable accommodations. Students have the responsibility for providing DSS personnel with documentation establishing their need for accommodations. Students benefit most when they understand the role of DSS offices, know their own capabilities and limitations, and actively assist in educating faculty and DSS personnel about their individual needs.

In scheduling classes, all students should consider how long it will take them to reach a class across campus. That could be a special consideration for students with disabilities, especially

on large campuses. If scheduling more time between classes is not an option, then the student needs to address this issue with the professor. Students with disabilities should preregister at the earliest opportunity to be sure their class schedule meets these and other logistic requirements. That may include scheduling interpreters and laboratory assistants, providing the DSS office with adequate time to obtain materials in an appropriate format, or other academic accommodations.

Students, DSS personnel, and faculty should work together to maximize the opportunity for success. The importance of that cooperation cannot be overemphasized. Faculty should understand that students with certain disabilities might have anxieties about taking laboratory courses. Professors can make a great difference in a student's life by providing reassurance, demonstrating acceptance, and expressing a willingness to be flexible. Faculty should also understand that while students new to the department are experts about their own disabilities, they probably lack knowledge about labs and classrooms. The student may need a period of familiarization with the new environment to identify necessary accommodations. Likewise, students should be open to new ideas and opportunities.

DSS offices, faculty, and peers may have useful new suggestions for accommodations. These new approaches may even work better than accommodations or strategies that the student has used in the past. Students also need to understand that the specific services and accommodations available at one institution are not necessarily available at another. Although accommodations are mandated under the law, specific accommodations for specific disabilities are not. Institutions have flexibility in selecting specific accommodations for specific disabilities.

6.9 The Importance of Self-Advocacy

In college, as noted above, students must self-disclose (if that's their decision) and seek out supportive services; they need to communicate to each of their professors their need for accommodations in the classroom. Again, that's often a major shift from the secondary school experience they're accustomed to, where school districts are responsible for identifying students with disabilities and then provide and monitor services to ensure student success.

Although advocating for themselves might be a skill that students learn while in secondary school, that shift often means they need to "step it up" in college life. Ten nonacademic behaviors are associated with postschool success for students with disabilities. Those behaviors include:[6]

1. Knowledge of strengths and limitations,
2. Actions related to strengths and limitations,
3. Disability awareness,
4. Employment,
5. Goal setting and attainment,
6. Persistence,

7. Proactive involvement,
8. Self-advocacy,
9. Supports,
10. Utilization of resources.

Research suggests that self-advocacy skills among students with disabilities are linked to better school retention rates and more successful adult outcomes.[7] Key to self-advocacy is the student's **disability awareness**, that is, understanding the specific characteristics of their disability, knowing how their disability affects the way they learn, accepting their need for support services, and having the ability to communicate this information to their professors. For example, a student identified with dyslexia or ADD should understand and be able to communicate how their disability affects their reading fluency and comprehension and why they would benefit from extended time on exams or taking the exam in a quiet, reduced-distraction environment.

6.10 Mentoring Students with Disabilities

Adviser. Teacher. Coach. Positive role model. Friend. Mentors are all that and much more. Many scientists looking back on the milestones in a successful career realize the essential roles that mentors played. Mentors' roles are multifaceted. Their overall impact is to encourage and sustain an interest in science and open doors to opportunities. Finding a suitable mentor may be the most critical step in a student's scientific career. Essential to the successful career of any scientist, mentoring is especially important for students with disabilities. They benefit from the typical mentoring that helps so many other students discover and develop a science career. In addition, students with disabilities need more targeted mentoring that addresses disability-specific issues. Some of these issues may involve intersectionality: dealing with a disability and gender identity or being a person from a different culture. Students may need assistance with knowing how to deal with these and similar issues.

Unfortunately, students with disabilities receive less mentoring than other students.[8] The reasons are complex and involve attitudinal barriers common to other underrepresented groups in science. This situation is indeed unfortunate, especially with the abundance of mentoring resources now available to students and teachers. Teachers are the key to making mentoring more available to students with disabilities. Faculty can explain the importance of mentoring to a career in science and help forge mentor–student relationships. In some instances, the student with a disability may wish to suggest the name of a faculty member or other individual who could serve as a mentor. In other instances, the teacher may suggest a mentor from academia or industry and help with the initial contact.

Some students with disabilities may relate best to a mentor who also has a disability and can serve as a specific role model. Long-distance mentoring relationships, with routine contact by email, online meeting platforms, or telephone, can work effectively. There is no specific requirement, however, for the mentor to be an individual with a disability.

Mentoring students with disabilities is similar to mentoring other students. Mentors and teachers should be aware that students with disabilities might have low self-esteem and lower-than-justified expectations, but this is changing as more employees with disabilities serve as role models. Out-of-classroom activities give students opportunities to identify, demonstrate, and document their unique skills. Some of their strengths typically include problem-solving abilities, perseverance, knowledge of negotiation strategies, and consensus building. Mentors and teachers should encourage students with disabilities to participate in out-of-classroom activities, including:

- membership in scientific societies, such as the ACS Student Affiliates program
- work-based learning opportunities
- summer internships or other work experiences
- undergraduate research projects
- campus organizations or interest groups that address the needs of students with disabilities
- presentation of research results at scientific conferences

6.11 College to Graduate School or Employment

The transition from college to graduate school or employment brings new challenges and opportunities for all students. Advance preparation for these milestones toward a successful career in chemistry is important for all, and especially so for students with disabilities. Some schools require graduate students to serve as teaching assistants (TA). Others give students a choice between serving as a TA and a research assistant (RA). Students with disabilities often can serve effectively as either a TA or RA. Preparation to perform these duties should be part of the undergraduate educational experience of all students with disabilities. It will prepare students for both graduate school and participation in undergraduate-research programs and other valuable out-of-classroom experiences.

Many graduate schools, and almost all employers, require interviews. All students will benefit from coaching on successful interview strategies. Students should, for instance, anticipate likely interview questions and mentally prepare "sound bites," brief but concise answers that can be stated without hesitation. Faculty can help with this process by suggesting likely questions, by participating in practice interview sessions, and in other ways.

Students with disabilities may benefit from coaching on additional topics. These include tactics for dealing with illegal, unethical, or intrusive questions, and how to address topics like their academic and laboratory performance abilities in relation to their needs for accommodation. Some students may know that employers cannot legally ask questions about their disabilities but can only ask whether the applicant is able to perform the essential functions of the job. Therefore, students with an obvious disability can benefit greatly during the interview by taking the initiative with a positive approach to the unasked question. “You might be wondering how I perform laboratory work. I’d like to tell you about the accommodations I have used which

enabled me to perform successfully and achieve the accomplishments mentioned in my resume."

One common dilemma involves the stage in the application process when it is most appropriate to disclose the existence of a disability. Students often are concerned that early disclosure of a disability may preclude their further consideration for the position. They worry, for instance, about being excluded before the personal interview, which provides an opportunity to address and resolve issues about fitness for the position. This topic is discussed in the following section.

Graduate faculty generally have extensive networks in academia and industry. These contacts include individuals who can help open doors for graduate students. Faculty networking can be especially helpful in eliminating barriers for their students with disabilities.

6.12 Employment

ACS offers employment assistance for members and is strongly committed to improving career opportunities for students with disabilities. Finding work in a competitive job market requires well-developed strategies, especially for chemists with disabilities. ACS provides helpful booklets, including one that addresses how Title I of the ADA affects the job search for individuals with disabilities. The ACS book, *Working Chemists with Disabilities,* describes employment strategies used by successful chemists with disabilities. *Working Chemists with Disabilities* can help students with disabilities understand their rights and responsibilities and reinforces the importance of their active participation in seeking mentoring and employment. It gives examples of simple strategies used by scientists with disabilities to become successful participants in the scientific endeavor.

Students with disabilities need to recognize the importance of developing job search and interview skills and preparing for disability-specific issues involved in the process, such as the appropriate time to disclose a disability. ACS provides an extensive array of excellent resources and career guides for students seeking employment.

Students with disabilities should be particularly aware of the employment resources available at ACS national meetings. These include mock interview sessions with ACS Career Services professionals, assistance with resume preparation, discussions with career consultants, extensive opportunities to interview with many actual employers on site, networking opportunities, and much more. Faculty mentors should note that ACS national meetings are accessible and provide employment resources in a setting that facilitates their use by students with disabilities.

Students with disabilities are often faced with the dilemma of when to disclose a disability and how to address essential functions of the job. Students should investigate this issue carefully, as there is no generic recommendation that works well in all circumstances. Fortunately, students can find many examples of individuals who have successfully addressed this issue. Helpful resources include the DO-IT program's career page and the ACS Employment Guides.

Students should also understand the law concerning disclosure and interviews. Consider, for instance, the student with a learning or other disability that is not readily apparent and does not require accommodations that affect the essential functions of the job. In that case, the individual need not disclose the disability until offered the job or the individual decides to seek accommodations. However, students with an obvious physical disability can find it advantageous to take the initiative at an early stage in the application process. They should discuss in a positive manner their previous accomplishments and how they will perform a job's essential functions.

Accomplished students with disabilities, nonetheless, often face an unwarranted credibility gap when seeking employment. Most companies and hiring managers have had little experience interacting in the workplace with scientists who have disabilities. Faculty can fill an important need by using their own networks to open doors and in assuring prospective employers of students' abilities. Faculty can be advocates for students with disabilities to ensure that they get job interviews and opportunities equal to those obtained by their nondisabled peers.

6.13 References

1. Meier, A.; Hartmann, B. S.; Larson, R. A Quarter Century of Participation in School-Based Extracurricular Activities: Inequalities by Race, Class, Gender and Age? *J. Youth Adolesc.* **2018**, *47*(6),1299–1316. DOI: 10.1007/s10964-018-0838-1 (accessed 2023-07-21)

2. *Disabilities, Opportunities, Internetworking, and Technology Home Page*. University of Washington. https://www.washington.edu/doit/ (accessed 2023-07-21)

3. American Association for the Advancement of Science. *Entry Point!* https://www.aaas.org/programs/entry-point (accessed 2023-07-21)

4. Woods, M. *Working Chemists with Disabilities, Expanding Opportunities in Science*; Blumenkopf, T.A., et al., Eds.; American Chemical Society: Washington, DC, 1996; ISBN 0841235023.

5. Chang, J. Review: Netflix's 'Crip Camp' chronicles the birth of the disability rights movement. *Los Angeles Times*, March 24, 2020.

6. McConnell, A.E.; Martin, J.E.; Juan, C.Y.; Hennessey, M.N.; Terry, R.A.; el-Kazimi, N.A.; Willis, D.M. (2012). Identifying Nonacademic Behaviors Associated with Post-School Employment and Education. *Career Dev. Exceptional Individ.* **2012**, *36* (3),174–187. DOI: 10.1177/2165143412468147 (accessed 2023-07-21)

7. Robert, A.J. *J. Res. Educ.* **2020**, *29* (2).

8. Agarwal, R.; Heron, L.; Naseh, M.; Burke, S.L. Mentoring Students with Intellectual and Developmental Disabilities: Evaluation of Role-Specific Workshops for Mentors and Mentees. *J. Autism Dev. Disord.* **2021**, *51* (4), 1281–1289. DOI: 10.1007/s10803-020-04599-w (accessed 2023-07-21)

Chapter 7: Blind and Low Vision

1. **Hoby Wedler,*[,1] Ashley Neybert,*[,2] Elizabeth Janney,[3] and Mona Minkara[4]**

[1]Wedland Group LLC, 1601 Corporate Circle #5807, Petaluma, CA 94954-9991
[2]Independence Science, 3000 Kent Ave., Suite 2706, West Lafayette, IN 47906
[3]College of Engineering, Northeastern University, 360 Huntington Ave., Snell Engineering Center, Boston, MA 02115
[4]Department of Bioengineering, Northeastern University, 360 Huntington Ave., ISEC Room 206, Boston, MA 02115

***Email: hoby@hobywedler.com**
***Email: aneybert@independencescience.com**

Chapter 7 Contents

7.1 Range of Needs
7.2. Accessibility Guidelines
7.3 Classroom Considerations and Adaptations
7.4. Testing and Evaluation
7.5. Laboratory Considerations and Adaptations
7.6 Assistive technology and Accessible Computing
7.7 Conclusion and Outlook
7.8 References

This chapter provides a resource teachers can turn to when they have a student who is blind or low vision in the chemistry classroom.

Various terms are used to describe the loss of eyesight, such as blind, lack of peripheral vision, limited vision, legally blind, low vision, and visually impaired. In this chapter, we use the words “blind and low vision” to refer to the spectrum of sight loss. Disability first language (i.e., a blind person) is often used instead of person-first language (i.e., a person who is blind).

7.1 Range of Needs

Loss of eyesight occurs in different forms and ranges of severity. Following is a subset of conditions related to sight loss:

- **Tunnel vision** is defined as defective sight in which objects cannot be properly seen if not close to the center of the field of view.[1]
- **Peripheral vision** is also known as side vision, or what is seen on the side by the eye when looking straight ahead.[2]
- **Color blindness** is a condition where the eye is unable to distinguish certain colors or sometimes any colors at all.[3]
- **Migraines** are severe headaches that can cause temporary vision loss.[4]

- **Legal blindness** is when best-corrected vision is less than 20/200.[5] This diversity calls for flexibility and basic knowledge about sight loss by high school and college classroom teachers. Instructors should be aware, for instance, that many blind individuals function independently except for reading and other sight-dependent tasks. Do not assume that sight loss makes the student helpless, no matter how severe.

  Often, classroom teachers and others in society do not understand blindness or how blind people cope in the world. To improve their understanding, they may participate in simulations to demonstrate what it is like to have eyesight temporarily removed. While this is a good starting point, it can inaccurately portray being blind as helpless. We believe that the best strategy is to learn from students who are blind about how to best accommodate them.

  Teachers more knowledgeable about blind students usually adopt the most effective teaching techniques.[6-7] There is not a one size fits all solution. What worked for one student will not necessarily work for another.

  > "I was born with no eyesight. No light perception or anything. Totally blind since birth. It's given me a wonderful opportunity to learn about the world as a blind person. I don't think I'd want to relearn the world as a sighted person." – Hoby Wedler, Ph.D.

  > "Some individuals with low vision can read text when it is enlarged. I am not able to read text. In addition, I did not learn braille as a child. Many websites and PDFs are not accessible to screen readers." – Mona Minkara, Ph.D.

  > "Sometimes, I look different. I'm very light-sensitive. I usually wear sunglasses and a hat indoors if there are any fluorescent lights. That's weird to a lot of people. I'm both low vision and light-sensitive. I want teachers to know that I'm not falling asleep. Fluorescent lights are made with an electron constantly going back and forth. Most people don't notice, but my brain can't process this, and I can have a migraine that looks like a seizure. People call 911, but there is nothing the hospital can do. What I need is a dark closet to refocus." – Ashley Neybert

  Teaching blind students can be facilitated with adequate course preparation, proper communication techniques, and specially adapted textbooks. Students who are blind often prefer using printed course materials converted into braille, large print, or digital recordings. Some Disability Student Services (DSS) offices can obtain textbooks in alternative formats and may have assistive technology available for student use. Students should submit a request for accommodations well in advance of the start of classes. Educators can often modify instructional exercises easily in the high school chemistry classroom.[8-9] In general, timely responses to student requests will ensure that a course is accessible and build rapport between students and teachers. The most important part about teaching students with disabilities is open communication and conversation between the student and teacher to identify how to best accommodate the student.

7.2. Accessibility Guidelines

> "Knowledge is what enables us to begin to level the playing field. All students need access to knowledge." - Mona Minkara, Ph.D.

For many blind children in the public education system, accessibility is a lifelong challenge. Public education systems must provide equal access to learning materials as part of The Individuals with Disabilities Education Act (IDEA) of 1975, The Rehabilitation Act of 1973, and the Information and Communication Technology (ICT) accessibility standards (See Chapter 2).[10-12] However, many schools face funding challenges, and many students face one-size-fits-all options that don't fit anyone very well.

National accessibility standards for teaching students with sight loss are somewhat ambiguous. We feel this ambiguity is a benefit because every student with sight loss learns differently and the best practices should be established between the student and teacher. Furthermore, it is a challenge to find one instrument that meets the needs of individuals who have hearing loss, sight loss, mobility impairments, etc. Accommodations often need to be individualized. People are left out when the standards are too prescriptive.

Also, guidelines vary by state. For example, the state program in Nebraska acquired talking lab equipment for all blind students. Texas passed a law that makes blind students eligible for a tuition waiver.[13] Furthermore, the University of Minnesota also waives tuition for legally blind students.[14] Many states require that the accessible versions of tools and texts be purchased when available even when those versions are more expensive.

Financial hardship for the school is not typically accepted as a reason to deny requests for reasonable accommodations; schools have to figure out a way to budget these items. Some ideas for finding funding for equipment are as follows:

- State government agencies, such as the commission for the blind or any vocational rehabilitation agency that supports the blind in leaving the permanent social security system may help to pay for resources.
- An advantage of using non-school agencies to purchase equipment is that the resource then belongs to the student. The student takes the resource with them through elementary, middle school, high school, and college. When the equipment belongs to the school, it stays with the school. If equipment is owned by the school system, it needs to be repurchased every time a student undergoes a transition in their education.
- Budget constraints can be difficult and need to be clearly discussed. Using the DSS office to purchase equipment, rather than the chemistry department, can be a benefit. This enables different departments to use and share the equipment. However, departments tend to have more discretionary funds to use for equipment. As stated before, equipment should be purchased on a case-by-case basis in order to make the most sense for the institution and give the student the most possible access.

- K–12 students can attend science camps for the blind and visually impaired. In particular, co-author Hoby Wedler and colleagues designed a chemistry camp held in Northern California for six years.[15]

7.3 Classroom Considerations and Adaptations

7.3.1 General Communication Techniques

Simple accommodations can significantly improve communication between teachers and blind students. Remember that students are often the best resource for clarifying their abilities and identifying the most suitable accommodations. Instructors can often learn a great deal about how best to accommodate students by conversing with them, identifying their skill levels, and asking them what works best. Instructors should encourage blind students to speak up when they don't understand something in lecture or lab. Begin each conversation with the student who is blind by identifying yourself and addressing the student by name. Talk directly to the student, just as you would any other individual. Use a normal volume and tone of voice and your regular vocabulary and syntax. Give the student your full attention during the conversation and look at the student. Students often will know if you are reading or engaging in some other activity during a conversation.

> "Sometimes, students are tired from eye fatigue. For some students, the brain is trying to process the material even when they can't see it – seeing, hearing, doing can get hard. I could either take notes or understand the material. No in between. Understand that students might close their eyes if they're low vision. I do this when I'm focusing because I want to cut out visual distractions and hear more. People can think I am sleeping, and this can be challenging for schools to work with." - Ashley Neybert

When walking with a blind student, ask if you can lend a hand with navigation. If the student accepts, offer the individual your arm just above the elbow relaxedly. The student can follow the motion of your body, which communicates changes in terrain and when you are stepping up or down.

> "When instructors were willing to explain things in a clear manner, and comfortable with me in the lab the class worked well for me. They would put my hand on their arm and we would walk through the lab together learning the layout and setup." - Hoby Wedler, Ph.D.

If the student uses a guide dog, remember that the dog and owner are part of a working team. Guide dogs are highly trained, obedient, well-mannered animals. Teachers can be assured that guide dogs will not disrupt lectures, laboratories, meetings, or other events. Guide dogs wearing a harness are not pets but working animals whose attention is focused on identifying possible safety hazards. To avoid distracting the dog, never pet, talk to, or feed a service dog. See Chapter 5 for more information on service animals.

Some individuals can feel a loss of autonomy when navigating with a white cane. Remember to ask blind students if they need assistance — they may or may not need assistance depending on their travel skill level and/or the specific activity or environment.

> “Kids get scared of using a white cane because they feel it points them out as different. People who should use a white cane but choose not to, often shuffle their feet so as not to trip or fall. However, if the blind person wishes to be more independent when traveling, using a white cane certainly makes a positive difference. When blind individuals use a white cane or guide dog properly, it builds up confidence.” - Ashley Neybert

Sighted students learn a lot of contextual and social cues by watching events in the classroom take place. Blind students need a different strategy to be successful. They need people to explain how and what they are doing in order to follow. Imagine a sighted student watching an instructor pour from a bottle into a beaker. They will learn the technique simply by watching. Blind students need this behavior to be explained.

> “So many kids learn from watching the adults in their life—parents, teachers, people in the community. Adults don't always realize what the kids are picking up. Sighted students can watch mom and dad open a door and see how doors work. Blind kids need to be shown these things. For example, blind individuals may not realize that round and flat objects are both doorknobs. A great way to teach some of these things is to have blind students touch things at a hardware store. It is important to help blind children build up tactile fluency.” – Ashley Neybert

7.3.2 Classroom Communication Techniques

Students should select a seat where they can best view the teacher and hear the lecture. Seating close to the lecturer is critical in poorly lit rooms, rooms where glare or unusual brightness interferes with optimal vision, or rooms with poor acoustics.

As in personal conversation, always call on the student by name in class, rather than pointing or gesturing. When referring to the material presented on projectors, whiteboards, or chalkboards, use an approach that is very helpful for all students, not just those with vision impairments. It involves making specific references to visuals. For example, say "benzene," not "this compound." Say "from 20 degrees Celsius to 40 degrees Celsius" instead of "from this temperature to that." State "in the reaction of benzene with bromine" rather than "in this reaction." An excellent account of the need for spoken expressions with good examples can be found in Emerson and Anderson’s paper “Using Description to Convey Mathematics Content in Visual Images to Students Who Are Visually Impaired.”[16] From experience, students should be encouraged by instructors to speak up when something is said that they don’t understand. If the teacher is stopped right when something is confusing, the remainder of the lecture will make more sense to the blind or low vision student. In the experience of our co-author Dr. Hoby Wedler, speaking up when the instructor did not provide adequate verbal information helped the entire class, not just himself.

> “Try recording a lecture and then ask someone to listen to the recorded lecture. Don't show them anything. If they can follow what you say throughout the recording, your lecture was accessible. Remember, the audio experience is what the blind student is getting. Use more descriptive words instead of pointing.” - Ashley Neybert

> “I took a physical chemistry class as an undergraduate student. We each took turns writing on the board and read aloud everything we wrote. Verbalizing the writing enables everyone to have access. The process went a little slower, but sighted students said it was much more helpful because they heard the words and had more time to process the information.” - Hoby Wedler, Ph.D.

> “Teach the students to call out their names instead of raising their hands. For example, when a student wants to speak, they call out their name (not the teacher's name), and then the teacher repeats their name back to call on them. This has unexpected benefits. Students learn each other's names which helps build classroom community.” - Ashley Neybert

When writing on chalkboards or whiteboards, high-contrast chalk and markers are essential for students with low vision and helpful for all students. Whiteboards are available with attached electronic devices that generate a printed copy of the board contents.[17] Once again, instructors can facilitate learning among all students by providing copies of the presentation, including chalkboard material and visuals.

Slideshow software allows manipulation of brightness, contrast, fonts, graphics, and colors, allowing choices that may be very helpful for students with low vision. Consult the student to determine the most visible format. Students with Irlen syndrome, also called scotopic sensitivity syndrome, for instance, are very sensitive to certain wavelengths of light.[18] They may benefit from using colored overlays to improve the contrast of presentations. The digital format also makes it easy to produce printed copies of a presentation or make the presentation available to students in an alternative format. Be aware, however, that many individuals who use presentation programs unconsciously speak rapidly, which can complicate the learning process for all students.

> “Recognize that with every action you are causing a ripple effect. Whether you like it or not, you are not neutral. What ripple are you making?” - Mona Minkara, Ph.D.

7.3.3 Course Preparation

Many college teachers already prepare for their classes in ways that help ensure access for students who are blind. These involve standard techniques for effective teaching such as preparation and frequent updating of a class syllabus, making course materials available to students in digital formats, posting course materials to a web page, and accepting assignments submitted as email attachments. These approaches also are becoming more common at the K–12 level. Some teachers prepare for all courses assuming that a blind student will enroll. The approach can save time and effort when such a student does enroll. It also offers greater accessibility to course materials and facilitates learning for all students.

> “Sometimes, you will have additional people in your classroom. When I was a student, I had a couple of access assistants in the classroom with me: an art student who made diagrams into 3D graphics and a student notetaker. I suggest using student note takers who are not in the class, but have taken the class before so they understand what’s

going on, but don't disadvantage a current student with additional duties." - Ashley Neybert

7.3.4 Essentials for Designing a Barrier-Free Course for Students Who Are Blind

> "I love multi-sensory learning and inclusive design work. There's nothing wrong with saying to the entire class, look, this changes colors. It smells different too. Integrating multiple senses into your lessons, promotes learning and retention for all the students." - Ashley Neybert.

Textbooks and other relevant course materials should be selected far enough in advance of a course start date to ensure that materials can be made accessible by Disability Services for Students (DSS) offices. When selecting a new textbook, consider texts available in both standard print and digital or recorded format. Access to the digital format can greatly reduce the time and expense of converting a text into braille or other alternative formats. Alternatives to the standard textbook format may also be necessary for students with certain learning disabilities. In Dr. Hoby Wedler's experience, reading textbooks with a live assistant vastly improved his ability to study quickly and thoroughly.

Check with the DSS office on the amount of time needed to convert printed materials into alternative formats. Be sure to send copies of the material to the DSS office within that time frame. Materials should be available to the student in an appropriate alternative format at the same time they are distributed in print to other students.

Prepare all classroom handouts as digital files that the instructor can easily convert into alternative formats. Digital formats are ideal for students with visual disabilities who use computerized assistive technology such as magnification or screen-reader software.

Provide lecture notes in an accessible digital format such as Microsoft Word Document (.doc or .docx)[19] or Portable Document Format (PDF).[20] When creating any file, make sure it is created using the specific vendor's accessibility guidelines. For example, when creating a PDF, documentation can be found on Adobe's website with specific instructions and examples.[21] Similar information can be found for Microsoft Word.[19] If created properly, these formats can be translated into audio using text-to-speech software such as JAWS for Windows,[22] NVDA,[23] and VoiceOver for MacOS.[24] Class websites with text annotations (Alt-Text) of graphics are also an excellent way to make notes and other material accessible.

Instructors who review solutions to problems during class should consider using Microsoft PowerPoint[25] (PowerPoint) rather than a chalkboard or standard whiteboard. Photocopies can be scanned into digital files and made available to all students, including those with vision impairments. Additionally, PDFs, PowerPoint[25] presentation slides, and other materials can be posted to the course website.

Remember that many students use Windows-compatible computers and may be unable to open files saved in Apple iWork proprietary file formats created by software such as Pages or Keynote.[26] Also, there may be compatibility issues with Windows, Apple, Unix, or other systems that faculty and students may use (campuswide systems may be Unix-based).

Print course materials using the paper and ink color combination that each student with low vision identifies as the most visible. In general, strive for high contrast and low glare. When using a course syllabus, include all dates for tests and due dates for assignments. If the schedule changes, distribute a revised syllabus to the class and the DSS office. DSS personnel often coordinate their schedules with the syllabus. They need to know if the schedule changes; if they are not informed about it, students may not have timely access to course materials. Remember that students who are blind or have low vision may wish to record lectures, even when they use a notetaker, so that they can annotate and personalize the notes. Encourage students to email completed assignments to the instructor. The instructor then should annotate the assignment with appropriate comments and return the graded work directly to the student by email. Remind students of your office hours. This is a terrific opportunity for a blind student to gain further knowledge and in-depth explanations.

7.3.5 Converting Textbooks to Audio Format

Converting textbooks to braille or large text format can be done, but it can be expensive. However, as shown below, there are several resources available to locate pre-recorded textbooks.

Many textbooks are currently available from Learning Ally.[27] Learning Ally is the nation's largest nonprofit organization providing textbooks and educational materials in audio-accessible formats for students who cannot read standard print effectively because of vision impairment, dyslexia, or other physical or learning disabilities.

Learning Ally's library includes more than 83,000 taped and electronic audio textbooks in various grade levels and academic subject areas. The organization's digital texts can be converted by text-to-speech computer software and read by a voice synthesizer. Electronic textbooks can also be enlarged for easier reading on a computer monitor. Alternatively, electronic textbooks can also be output to braille embossers or refreshable braille displays such as the Basic Index Embosser[28] or Humanware's Q Braille XL braille display.[29] Learning Ally circulates about a quarter-million accessible textbooks to its 300,000 members annually. If a text is not already available in audio format, Learning Ally may convert it. This recording service is free to institutional and individual Learning Ally members. The time necessary for conversion varies on several factors, including the book's length. This need for adequate lead time is why teachers must select textbooks months in advance and make the selections known to the DSS office. Learning Ally can provide additional information about conversion times. Another useful resource for electronic audio and braille textbooks is Bookshare.[30] If needed, students can use volunteers on apps like Aira[31] and Be My Eyes[32] to read textbooks through the back camera on their smartphones.

Suppose not enough lead time exists for this option. In that case, consider hiring knowledgeable local assistants or volunteers to record textbooks locally using a digital voice recorder. Educators can also convert texts to e-text by scanning to a file saved in text format. Readers should remember the following:

- When reading mathematical equations, it is important to indicate the numerator and the denominator of all fractions and be clear about the quantities being multiplied, divided,

added, or subtracted. Read any parentheses by stating “the quantity of” for what’s in parentheses and all elements of the mathematical equation that could be useful. For example, the following equation:

$[3(x + 4)^2]/2 = 18$

can be read as: “three times the quantity of x plus 4, quantity squared, divided by two equals eighteen. Here, we explicitly mention fractions, quantities in parentheses, and exponents.

- If a sentence is broken over two pages, finish reading the sentence before stating the next page number.
- Read all subheadings, footnotes, and references.
- When reading tables, read the titles of tables, then the titles of each column or row before reading the data that are being presented. It should be left up to the reader to decide the most logical way to verbalize the material and describe chemical and other technical notations.
- When describing pictures or illustrations within the text, the reader should state figure and caption numbers before starting a verbal description of the image. After completing a verbal description of the image, the reader should say "return to text" to indicate a return to the text material. If the reader is unable to provide an adequate description of the image, he or she should simply read the caption. When possible, a tactile image can be provided to supplement the recordings, such as a raised-line drawing (see sidebar, Accessible overheads and other visual aids).

7.3.6 Accessible Visual Aids

Using visual aids in the classroom and illustrations in text reinforces information by providing it to students in different ways. Even though the student may have difficulty seeing, visual aids should still be incorporated into lessons when possible. Blind or low vision students have many ways of learning from tactile graphics, including raised-line drawings.[33-34] For additional and, perhaps, more modern techniques for creating tactile graphics, see co-author Hoby Wedler’s paper “Applied Computational Chemistry for the Blind and Visually Impaired.”[35] Students can also learn from visual aids in class if the instructor gives a detailed oral description of the material. Consistently describe such material, such as clockwise or left-to-right. 3D models of structures described in class also can be helpful for blind students.

A variety of accessible visual aid technologies exist, including talking scientific calculators, graphical methods of presenting scientific and mathematical information for the blind, 3D printers, and options such as embossers which print standard print and braille simultaneously. (See the section, *Assistive Technologies*, for more resources.) If such advanced technology is unavailable, visual aids can often be made more accessible to blind students in other ways. Faculty on many campuses use work-study students or student assistants to make raised-line drawings and other alternative formats. The following are among the approaches often used to create accessible visual aids:

- Verbal descriptions of all figures and graphics, including those on the board or on PowerPoint[25] slides. The figures and graphics should be numbered and referred to by number to simplify note taking.

- Raised figures and graphs can be prepared with glue guns, tracing wheels, clipboard and foam, the APH Draftsman,[36] or Wikki Stix.[37]

- A technique for creating simple and information rich tactile figures is to use a notebook, a pen, and a sheet of thick printer paper. Have an assistant draw the image about 300% magnified, and then flip the paper over on a soft surface. Then, trace the image from the back while pressing hard, creating raised lines on the front side of the paper.[35]

- Other inexpensive materials, such as pegboards, golf tees, and rubber bands, could be used to prepare excellent tactile graphics and figures. Small portable whiteboards are handy for drawings that low vision students can hold at the best viewing distance.

- A felt board with hook & look shapes can be a highly effective aid for illustrating structural formulas.[38]

- Clipboards wrapped in wire mesh can be used to make tactile figures and graphs. Wrap wire mesh around the clipboard to form a "screen," clip a sheet of paper over the screen, and draw with a crayon by pressing down hard. The resulting raised lines will serve as a tactile design.

- Electronic whiteboards are available for use in lecture classes. Connect these displays to a laptop computer for accessibility.[17] A refreshable braille display connected to the computer, or other technology, will make the visuals immediately accessible.[29]

- A variety of line formats and color-coding enhances the distinction between multiple lines on the same graph. Plots can be created in colored solid lines, dotted lines, dashed lines, and so forth.

- Encourage the student to examine the setup through touch whenever possible during demonstrations. In addition, use clear verbal descriptions of what happens during the demonstration, including color changes, gas releases, crystal formation, and precipitations.

- Give verbal descriptions of videos used in class or lab. Some videos are available commercially in this format through organizations such as the Public Broadcasting Service[39] and the National Geographic Society.[39] WGBH Media Access Center and EASI provide video transcribing services.[40]

- The American Printing House for the Blind produces a braille and large-print periodic table which is useful to blind and low vision students alike.[41] 3D printed accessible periodic tables also exist and can be printed by users with any 3D printer.[42]

7.4. Testing and Evaluation

> "We are taught that to be accommodating means lowering expectations. Instead, maintain your high expectations but understand things may happen differently." - Mona Minkara, Ph.D.

Most students who are blind can take examinations with minor modifications, which might include:

- Using pre-recorded audio or braille test questions, with the student recording answers in braille or auditorily.
- Tests can be given in print, accompanied by a reader/scribe, to both read the question to the student and to write the student's answer on the exam.
- Using talking calculators equipped with an earpiece.
- Using a computer or writing guide.
- Printing tests in large print and high contrast.

Testing students who are blind or have low vision can require advance planning. Some low vision students may need paper of nonstandard size. A braille test version can be generated quickly from a digital file using widely available text-to-braille software such as Duxbury System Inc.'s Duxbury Braille Translator (DBT).[43] If the software does not include scientific and mathematical braille, upgrade this for the science classroom. Educators should ensure that the software performs an accurate and complete conversion to braille.

Remember that the language of chemistry is not purely descriptive, and errors can occur. A graduate or advanced undergraduate can help by checking the translation with the aid of a braille reader. When the necessary software or hardware is unavailable, human transcribers can convert tests into braille.[44] Still, they should be contacted well in advance to find out the amount of time they require.

Some students may benefit from additional accommodations, such as a qualified reader knowledgeable about the subject. Graduate students taking qualifying examinations need readers who are highly knowledgeable in the field.

Testing in some topics and for some students may involve providing tactile graphics or 3D models. These, of course, must be prepared in advance of the test. There are different methods for creating tactile images and models:

- Tactile graphics can be printed off an embosser
- Molecular modeling kits
- Educators can produce DIY tactile graphics by enlarging and printing the image on paper and then tracing the graphic with a hot glue gun. Enlarge the image 4-5x and print only one image per page.[36]

> “The ViewPlus SpotDot[45] is an embosser that creates raised line graphics but prints on the same paper, enabling blind and sighted students to work together using the same document. Inkjet printing is helpful because it dries quickly, doesn’t get on your hands, and sighted teachers and sighted students can see the graphic.” - Ashley Neyburt

7.5. Laboratory Considerations and Adaptations

Many students with visual disabilities have successfully completed chemical laboratory work and regard the hands-on experience as a vital and enjoyable part of their education. For them, organization and consistency—such as placing all materials in a consistent location—greatly enhanced the laboratory experience. To help maintain a safe working environment, these students, like all personnel, are always required to wear safety goggles or glasses in the laboratory, even when they are not doing lab work themselves.[46]

Students who are blind navigate best in familiar surroundings and should become familiar with the entire laboratory, including seldomly-visited areas. Ideally, this process should begin before the first scheduled lab session, with the lab instructor identifying lab benches, sinks, reagent shelves, hoods, eye wash stations, safety showers, emergency exits, and other features. The instructor should identify the laboratory locations with the most significant potential hazards to the blind or visually impaired student. Educators can also use this orientation session to pick the most effective workstation for the student, discuss safety rules, and outline fire drills and other procedures. Instructors should also require that supplies in the lab including reagent containers, gloves, etc. be put back in the same place they were found so that blind or visually impaired students have an easy time finding them. Give the student time to learn to navigate the laboratory, remember the location of exits, learn the bench configurations, memorize the positions of the utilities, and become familiar and comfortable with the surroundings. If the student requires a full-time laboratory assistant, the educator should include the assistant in the orientation.

> “Don't change the classroom design. A significant part of lab safety involves putting things down where you found them and not moving them around. Maintaining predictable pathways through the lab space is also something to pay attention to. If pathways are not clear, students with visual impairments may bump into things and spill chemicals. As an aside, similar to the laboratory environment, pathways throughout the campus environment should be kept clear when at all possible. Remember who is using your paths when planning construction projects on campus. Construction materials obstructing paths on campus can interfere with safety and accessibility.” - Hoby Wedler, Ph.D.

> “Another important safety tip is to clean up spills immediately. I don't want to find a surprise when I set my hand down on the table.” - Hoby Wedler, Ph.D.

> “I number all of the tables and the supply station in my laboratory. When students walk with materials in the lab, I teach them to say, for example, ’carrying a beaker of sulfuric acid from the supply cabinet to bench number one.’ They repeat this phrase until they get to their destination. Using verbal cues also benefits sighted students who may overlook their peripherals. There are many clear and colorless substances in a lab. In

the event of a chemical spill, knowing exactly what chemical spilled helps instructors understand what safety datasheet to use." - Ashley Neybert

Guide dogs should be permitted in the laboratory, taking proper safety precautions. Guide dogs need to have their own area and must be required to wear their own personal protective equipment. For information on service animals in chemistry laboratories or classrooms, refer to Chapter 5.

Blind and low vision students sometimes must observe an experiment at close range. They should always use a full-face safety shield when doing so. In some instances, it will be safer if other students, the instructor, or a lab assistant provides a verbal description of equipment setup, chemical reactions, and other aspects of an experiment.

For more detailed information, the ACS article, co-authored by Hoby Wedler, "The value of safety and practicality: Recommendations for training disabled students in the sciences with a focus on blind and visually impaired students in chemistry laboratories," provides a comprehensive and practical resource on working with blind and low vision students in the chemistry lab.[47]

7.5.1 Simple Accommodations

Some students with sight loss may require either minimal assistance and accommodations or, possibly, no special laboratory assistance at all. Minimal accommodations could include such accommodations as large print on reagent bottles, a magnifying glass to read burettes, a large-size lab notebook, or a lab station in a well-lit area. Numerous other simple, low-cost accommodations can enhance these students' laboratory experiences:

- Titrations can be done with a standard pH meter rather than a colored indicator or based on mass or time measurements. Laboratory exercises incorporating sound or smell "level the playing field" for the student with a vision disability and broaden classmates' experience.[15,48-52]

- Volume measurements can be done with liquid level indicators such as a flotation device (FOSS) in a graduated cylinder, volumetric pipettes, repipetters, or volumetric syringes.

- Solid reagents can be transferred using spoons with sliding covers to prevent spillage.

- Large-print or braille thermometers or high-power magnifiers can facilitate reading the scale on thermometers.

- Reagent bottles can be labeled in large print or braille. Students can use sandpaper labels for hazardous chemicals. Some laboratory glassware is available with raised numbers or with etched-glass labels.

- Electronic balances can be equipped with a large print display or speech output through an application on an accessible smartphone.

- Instructors or assistants can use a glue gun for tactile recognition.[36]
- Digital output from electronic balances, thermistors, voltmeters, and multimeters that can interface with computers may be converted to speech output.
- Bunsen burner adjustments can be based on audible cues recognizable to many students with vision disabilities.
- The dials on electric hot plates can be marked with tactile increments.
- Effervescence is audible in macroscale experiments and can be heard with a microphone and amplifier in microscale experiments.
- Properly placed staples can easily make standard meter sticks more readable. Braille rulers and meter sticks are also available.
- Scanners are available to digitize gels and chromatograms.
- Talking calculators and other electronic products with voice output not only are helpful to students with visual disabilities but also can increase efficiency and decrease errors when used by those without sight loss.
- Measuring devices include talking thermometers and kitchen scales that can be used for lab activities that do not require ultra-accurate measurements.
- Add braille tags to spring scales.
- Logger Pro (Vernier) and Independent Science instrumentation with audio output can be used to measure a variety of important data points in the chemistry laboratory.

"I use disposable aluminum roasting pans to keep my materials organized." - Ashley Neybert

More specialized equipment and products that facilitate students' laboratory work are constantly developing. Excellent illustrated reviews of this special equipment, designed for use in high school laboratories, are available.[55-60] A wide variety of laboratory instruments with computer interfaces provide an intermediate level of accommodation that allows the student to work in the laboratory more independently if the output is compatible with their existing assistive technology.

7.6 Assistive technology and Accessible Computing

Blind and low vision students will learn chemistry in the classroom and laboratory best and enjoy the most productive careers when they have access to the proper combinations of computer hardware, software, and other assistive technology.[38,61-62] Visual impairments

should not be a barrier to learning. Chemists who are blind use assorted assistive technology to work productively and safely in academia and industry.[63]

"Look for strength. Find the advantage, not the lack." - Mona Minkara, Ph.D.

Many adaptations are simple and readily available. Anti-glare screens can make monitors easier to read. Software reconfigurations or special software can convert screens to a high-contrast output for easier reading for individuals who are light-sensitive. Many of the accessibility features in computer operating systems and other programs are also useful for those with vision disabilities.

In Microsoft Windows, for instance, Accessibility Options, found on the Control Panel screen, includes several adjustments that can make computing more accessible for blind or low vision individuals. Voice output can be used to read text on the screen to users who are blind. Refreshable braille displays provide word-by-word translation of text on the screen into braille on a separate display. The display reproduces words in the format of vertical pins that raise and lower to form braille characters in real time as the text is scanned. Braille embossers can provide hard copy output.

Graphics like organic chemical structures and bar and line graphs can be printed using a variety of tactile techniques including braille and raised-line diagrams. Scanners with compatible Optical Character Recognition (OCR) software can be used to read printed materials and store them electronically on computers where they can be read using text-to-speech software. Alternatively, scanned documents can be converted to either large print or braille. Such systems provide independent access to abstracts, journals, syllabi, and homework assignments. There are, however, limitations in the capabilities of OCR software to recognize scientific and mathematical content as of the publication date of this eBook.

- Many OCR reading packages and software do not currently allow users to scan and convert technical information like chemical and mathematical equations into speech;
- Many current OCR software packages are not capable of providing descriptions of pictures and other technical figures.
- OCR software can struggle to convert handwritten materials.

While the limitations above should be noted, OCR software has come a long way in the past few years and can provide a large amount of data even when scanning text or images with a smartphone camera. Microsoft's SeeingAI is an excellent OCR application for decoding complicated text and images.

Keeping current with newly published research once was a major problem for students with vision impairments. In the past, scientific journals were immediately available only in print

format. That barrier has been somewhat reduced with the immediate online availability of journals in electronic formats like HTML and PDF files, which, if saved in an accessible format, can be read by screen reading software. However, current screen reader software may share some of the same deficiencies as OCR software discussed above. Complex graphics and some other sections of online material may still require the use of a human reader or sufficiently written alt-text to be fully accessible to individuals with visual disabilities.[65] This is due in part to the fact that no standard requirements for figure creation and alt-text to describe figures are in place for most online publications.

7.6.1 Assistive Technologies

Students with visual disabilities often use assistive technologies including the following:

- *Braille print output* - Index Braille Embosser (Access Systems International) prints PC output in braille. Duxbury allows the computer to translate text into braille format and send it to the braille embosser.[28]
- *Refreshable Braille display*[29]
- *Large print keyboard retrofit labels* - Keys can be enlarged using large-print keytop labels.
- *Printed text Enlargement* - Printed text can be magnified using a wide array of handheld and desktop devices as well as screen magnification softwares.[67]
- *Screen enlargement* - Large monitors and programs like those offered by Freedom Scientific can be used to enlarge the output of a computer screen.
- *Screen readers* - Screen readers like VoiceOver for MacOS,[24] JAWS for Windows,[22] NVDA,[23] and others allow blind and low vision users to navigate a graphical user interface using text-to-speech output and other audible cues.
- *Speech input* - Dictate features available in Microsoft Word,[69] Google Workspace,[70] MacOS,[71] as well as software like Nuance Dragon Speech Recognition Solutions[72] provide a means of writing using speech instead of keyboard input.
- *Perkins Brailler*[73] - This standard braille typewriter was invented in the 1950s but remains the most useful tool for solving math and science problems by hand.
- *Braille Notetakers* - Humanware's Braillenote Touch and similar technologies are a useful tool for keeping track of information and storing a variety of information.[74]
- *3D Printers* – These are extremely useful for creating tactile graphics and virtually any 3D structure for students to examine tactilely.[62,75-76]

7.6.2 Additional Resources

7.6.2a Talking Calculators

A variety of talking calculators including the Orion TI-84 Plus from Texas Instruments exist on the market. Texas Instruments also manufactures a wide variety of accessible products.[77] Many notetakers also have scientific calculators which are very accessible.[74]

7.6.2b Eye Protection in the Lab

Low vision students might need special types of laboratory goggles to accommodate thick glasses.

> "I wear sunglasses, so I need fancier lab goggles. Otherwise, everything is polarized with my sunglasses, and I see rainbows everywhere. I use Honeywell Uvex Flex Seal® Safety Goggles[78] and find these to be the most helpful. I can wear my sunglasses without any additional issues. They are more expensive, but I've used the same pair for a long time." - Ashley Neybert

Some researchers use a monocle, which is helpful for observing experiments. Using a monocle and working in a glove box, so things can come close to your face without getting them in your eyes, can work well for low vision individuals.

7.6.2c Glove box has gloves built into the box in such a way that enables users to place their hands inside the gloves and then perform tasks inside the box without risk of exposure to chemical substances inside the box.

7.6.2d Tactile Modeling Kits enable the creation of tactile molecules when tactile graphics are difficult to produce.

7.6.2e Audio Described and Captioned Videos are useful teaching aids for low vision and hard-of-hearing students.

> "Make sure your videos are all described. I remember the teacher playing a film in class and I heard music while the other students watched how molecules go together. Record your class with an audio recorder to check accessibility."[40] – Ashley Neybert

7.6.2f Most Common Writing Utensils

- *Slate and stylus* is a portable way to write in braille. A slate snaps around a piece of paper and provides a template of braille cells. Braille dots are formed in these templates by using a stylus to punch out the paper.[79]

- *Perkins Brailler* is the most widely used mechanical braille writer in the world since its invention in 1951. It is the most useful tool for solving math and scientific problems in braille.[73]

- *Braille Notetakers* are portable devices with built-in refreshable braille displays that connect to the internet and have applications that allow users to perform school, office, or personal tasks on the go.[74]

7.6.2g Software

- *Sci-Voice Talking LabQuest* from Independence Science is a small and portable device which announces data collection in real-time. The device includes features such as file menu navigation, data table creation, a full periodic table, etc.[54] The device is durable enough to be used in any field or lab experiment. Data can be exported to the *LoggerPro*® software on a computer for statistical analysis.

- *Sci-Voice Talking LoggerPro* from Independence Science leverages the powerful Job Access with Speech or JAWS text-to-speech screen reader software along with the Vernier Software & Technology LoggerPro scientific data collection software to provide a powerful science access solution for quantifiable data collection in the science laboratory. The device also works with a braille display.

- *Software updates* – Be aware that developers might make changes to software without testing for blind or low vision users.

  "Recently, Microsoft updated their Office applications. Math Type enables students to read equations in braille or go through them letter by letter using JAWS. Microsoft made an update that autosaves equations as an image file which is not accessible." - Ashley Neyburt

7.6.2h Blind Scientist Tools is an encyclopedic reference of the tools and methods blind scientist Mona Minkara, Ph.D. has used throughout her journey from chemistry student to Professor of Bioengineering.[60]

7.7 Conclusion and Outlook

As was detailed throughout this chapter, there is no "one size fits all" approach for teaching chemistry to students who are blind or have low vision. As instructors, it is best that you learn what is best for your students and teach them what works best for you. By creating a strong, dynamic working team with your student who is blind or has low vision, you will be setting yourself and your student up for success.

The bottom line is that all students' accommodations are slightly different. If you ask questions, listen to your student, are nimble, and are able to adapt your teaching practices, you will be an excellent instructor to a student who is blind or has low vision. The most important aspects are to accommodate the student appropriately, to take safety first, and to enjoy the experience of teaching someone who is blind or visually impaired. From technology used to succeed to live readers, tactile graphics, and many more teaching solutions, each student's learning style will be different, and this chapter serves as a guide to navigate the many different learning styles and accommodation needs.

Never be afraid to ask your students how you are doing as an instructor. They will tell you. By checking in with them, you will always know what is working and where things could use some improvement. Ultimately, we wish to help you embrace the opportunity to teach someone with a vision disability. Have fun with it. You will learn just as much from them as they will learn from you. We hope this chapter has been informative, and we encourage you to reach out to any of us with questions along your teaching journey.

7.8 References

1. What causes tunnel vision, and what are the treatments? *Medical News Today.* https://www.medicalnewstoday.com/articles/tunnel-vision (accessed 2023-07-21)

2. Peripheral Vision. *Science Direct*. https://www.sciencedirect.com/topics/computer-science/peripheral-vision (accessed 2023-07-21)

3. Color Blindness. *Cleveland Clinic.* https://my.clevelandclinic.org/health/diseases/11604-color-blindness (accessed 2023-07-21)

4. Migraines. *Mayo Clinic.* https://www.mayoclinic.org/diseases-conditions/migraine-headache/symptoms-causes/syc-20360201 (accessed 2023-07-21)

5. What is legal blindness? *Vision Aware.* https://visionaware.org/your-eye-condition/what-is-legal-blindness/ (accessed 2023-07-21)

6. Ediyanto; Kawai, N. Science Learning for Students with Visually Impaired: A Literature Review. *J. Phys.: Conf. Ser.* 2019, *1227*, 012035. DOI: 10.1088/1742-6596/1227/1/012035 (accessed 2023-07-21)

7. *Foundations of Low Vision: Clinical and Functional Perspectives*, 2nd ed.; Corn, A.L., Erin, J.N., Eds; AFB Press, 2010.

8. Kizilaslan, A.; Sozbilir, M.; Zorluoglu, S. L. Making Science Accessible to Students with Visual Impairments: Insulation-Materials Investigation. *J. Chem. Educ.* **2019**, *96* (7), 1383–1388. DOI: 10.1021/acs.jchemed.8b00772 (accessed 2023-07-21)

9. *Science Teaching in Inclusive Classrooms: Theory and Foundations and Science Teaching in Inclusive Classrooms: Models and Applications*; Stefanich, G.P., et al., Ed.; Woolverton Printing, 2001.

10. *Individuals with Disabilities Education Act (IDEA).* https://sites.ed.gov/idea/about-idea/ (accessed 2023-07-21)

11. U.S. Equal Employment Opportunity Commission. *The Rehabilitation Act of 1973, Sections 501 and 505.* https://www.eeoc.gov/statutes/rehabilitation-act-1973 (accessed 2023-07-21)

12. Federal Register. *Information and Communication Technology (ICT) Standards and Guidelines*, FR Doc. 2017-00395. https://www.federalregister.gov/documents/2017/01/18/2017-00395/information-and-communicaton-technology-ict-standards-and-guidelines (accessed 2023-07-21)

13. *College for All Texans Home Page.* http://www.collegeforalltexans.com/apps/financialaid/tofa2.cfm?ID=547 (accessed 2020-07-21)

14. University of Minnesota, Crookston Campus, Financial Aid and Scholarships. Tuition Waiver Assistance for Blind or Deaf Students Application. *University of Minnesota*, 2016. https://onestop.crk.umn.edu/finances/types-financial-aid/grants-and-waivers (accessed 2020-07-21)

15. Wedler, H.; Boyes, L.; Davis, R.L.; Flynn, D.; Franz, A.; Hamann, C.S.; Harrison, J.G.; Lodewyk, M.W.; Milinkevich, K.A.; Shaw, J.T.; Tantillo, D.J.; Wang, S.C. *Nobody Can See Atoms: Science Camps Highlighting Approaches for Making Chemistry Accessible to Blind and Visually Impaired Students. J. Chem. Educ.* **2014***, 91* (2)*,* 188–194. DOI: 10.1021/ed300600p (accessed 2020-07-21)

16. Emerson, R.W., and Anderson, D.L. Using Description to Convey Mathematics Content in Visual Images to Students Who Are Visually Impaired. *J. Visual Impairment Blindness,* **March–April 2018**, 157–168*.* https://files.eric.ed.gov/fulltext/EJ1175990.pdf (accessed 2020-07-21)

17. Solvie, P.A. The Digital Whiteboard: A Tool in Early Literacy Instruction (Teaching Tips department). *The Reading Teacher* **2004**, *57* (5), 484–487. https://www.readingrockets.org/topics/educational-technology/articles/digital-whiteboard-tool-early-literacy-instruction (accessed 2020-07-21)

18. *Irlen: Where the Science of Color Transforms Lives*. https://irlen.com/what-is-irlen-syndrome/ (accessed 2020-07-21)

19. Microsoft Support: Make Your Word Documents Accessible to People with Disabilities. *Microsoft.* https://support.microsoft.com/en-us/office/make-your-word-documents-accessible-to-people-with-disabilities-d9bf3683-87ac-47ea-b91a-78dcacb3c66d (accessed 2020-07-21)

20. Adobe Accessibility: PDF Accessibility Overview. *Adobe.* https://www.adobe.com/accessibility/pdf/pdf-accessibility-overview.html (accessed 2020-07-21)

21. Adobe: Create and Verify PDF Accessibility (Acrobat Pro). *Adobe.* https://helpx.adobe.com/acrobat/using/create-verify-pdf-accessibility.html (accessed 2020-07-21)

22. *Freedom Scientific Home Page*. https://www.freedomscientific.com/ (accessed 2020-07-21)

23. *NV Access Home Page.* https://www.nvaccess.org/ (accessed 2020-07-21)

24. Chapter 1: Introducing VoiceOver. *Apple.* https://www.apple.com/voiceover/info/guide/_1121.html (accessed 2020-07-21)

25. Microsoft 365 PowerPoint. *Microsoft.* https://www.microsoft.com/en-us/microsoft-365/powerpoint (accessed 2020-07-21)

26. Apple iWork. *Apple.* https://www.apple.com/iwork/ (accessed 2020-07-21)

27. *Learning Ally Home Page.* https://learningally.org/ (accessed 2020-07-21)

28. *Index Braille.* https://www.indexbraille.com/en-us/braille-embossers (accessed 2020-07-21)

29. *Emerald Coast Vision Aids.* https://emeraldcoastvisionaids.com/shop/products/qbraille-xl-40-cell-refreshable-braille-display/ (accessed 2020-07-21)

30. *Bookshare Home Page.* https://www.bookshare.org/cms/ (accessed 2020-07-21)

31. *Aira Home Page*. https://aira.io/ (accessed 2020-07-21)

32. *Be My Eyes.* https://www.bemyeyes.com/ (accessed 2020-07-21)

33. Edman, P. *Tactile Graphics*; American Foundation for the Blind, 1992.

34. Tactile Graphics Technology. *Teaching Students with Visual Impairments LLC.* https://www.teachingvisuallyimpaired.com/tactile-graphics-technology.html (accessed 2020-07-21)

35. Wedler. H.; Cohen, S.R.; Davis, R.L.; Harrison, J.G.; Siebert, M.R.; Willenbring, D.; Hamann, C.S.; Shaw, J.T.; Tantillo, D.J. Applied Computational Chemistry for the Blind and Visually Impaired. *J. Chem. Educ.,* **2012**, *89* (11), 1400–1404. DOI: 10.1021/ed3000364 (accessed 2020-07-21)

36. Hospital, L. *Making Quick and Easy Raised-Line Drawings.* Perkins School for the Blind eLearning, 2023. https://www.perkins.org/resource/making-quick-and-easy-raised-line-drawings/ (accessed 2020-07-21)

37. Wikki Stix for the Sight-Impaired. *Welcome to Wikki Stix.* https://www.wikkistix.com/sight-impaired/ (accessed 2020-07-21)

38. Laconsay, C.J.; Wedler, H.B.; Tantillo, D.J. Visualization without Vision – How Blind and Visually Impaired Students and Researches Engage with Molecular Structures. *J. Sci. Educ. Stud. Disabil.* **2020**, *23* (1), 1–21. DOI: 10.14448/jsesd.12.0012 (accessed 2020-07-21)

39. The Audio Description Project. *American Council for the Blind.* https://adp.acb.org/streaming.html (accessed 2020-07-21)

40. Media Access Group at WGBH – Creating Captioned and Described Content. *GBH Educational Foundation.* https://www.wgbh.org/foundation/media-access-group-at-wgbh-creating-captioned-and-described-content (accessed 2020-07-21)

41. "Periodic Table" Search Results. *American Printing House.* https://www.aph.org/search-results/?fwp_search_term=periodic+table (accessed 2020-07-21)

42. Braille Periodic Table 3d Models. *STLFinder.* https://www.stlfinder.com/3dmodels/braille-periodic-table/ (accessed 2020-07-21)

43. Duxbury DBT: Braille Translation Software. *Duxbury Systems Inc.* https://www.duxburysystems.com/ (accessed 2020-07-21)

44. Braille Transcription Resources. *National Federation of the Blind.* https://nfb.org/resources/braille-resources/braille-transcription-resources (accessed 2020-07-21)

45. VP SpotDot. *ViewPlus.* https://viewplus.com/product/vp-spotdot/ (accessed 2020-07-21)

46. *Safety in Academic Chemistry Laboratories*, 8th ed.; American Chemical Society Committee on Chemical Safety, American Chemical Society: Washington, DC, 2017. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf (accessed 2020-07-21)

47. Nepomuceno, G.; Decker, D.; Shaw, J.; Boyes, L.; Tantillo, D.; Wedler, H. The Value of Safety and Practicality: Recommendations for training disabled students in the sciences with a focus on blind and visually impaired students in chemistry laboratories. *J. Chem. Health Saf.* **2016**, *23* (1), 511. DOI: 10.1016/j.jchas.2015.02.003 (accessed 2020-07-21)

48. Blumenkopf, T.A.; Swanson, A.B.; Larsen, R.P. Mobility-handicapped individuals in the college chemistry curriculum: Students, teachers and researchers. *J. Chem. Educ.* **1981**, *58* (3), 213–221. DOI: 10.1021/ed058p213 (accessed 2020-07-21)

49. Wood, J.T.; Eddy, R.M. Olfactory Titration. *J. Chem. Educ.* **1996**, *73* (3), 257–258. DOI: 10.1021/ed073p257 (accessed 2020-07-21)

50. Hiemenz, P.C.; Pfeiffer, E.A General Chemistry Experiment for the Blind. *J. Chem. Educ.* **1972**, *49* (4), 263–265. DOI: 10.1021/ed049p263 (accessed 2020-07-21)

51. Neppel, K. N.; Oliver-Hoyo, M. T.; Queen, C.; Reed, N. A Closer Look at Acid-Base Olfactory Titrations. *J. Chem. Educ.* ***2005***, *82* (4), 607–610. DOI: 10.1021/ed082p607 (accessed 2020-07-21)

52. *Oliver-Hoyo Chemistry Education Research.* https://oliverhoyo.wordpress.ncsu.edu/publications/ (accessed 2020-07-21)

53. Logger Pro 3. *Vernier.* https://www.vernier.com/product/logger-pro-3/ (accessed 2020-07-21)

54. *Independence Science Home Page.* https://independencescience.com (accessed 2020-07-21)

55. Tombaugh, D. Chemistry and the visually impaired: Available teaching aids. *J. Chem. Educ.,* **1981**, *58* (3), 222–226. DOI: 10.1021/ed058p222 (accessed 2020-07-21)

56. Supalo, G.A.; Mallouk,T.E.; Amorosi, C.; Rankel, L.; Wohlers, H.D.; Roth, A.; Greenberg, A. Talking Tools to Assist Students Who Are Blind in Laboratory Courses. *J. Sci. Educ. Stud. Disabil.* **2007**, *12* (1), 27–32. DOI: 10.14448/jsesd.01.0003 (accessed 2020-07-21)

57. Lunney, D.; Morrison, R.C. High technology laboratory aids for visually handicapped chemistry students. *J. Chem. Educ.,* **1981**, *58* (3), 228–231. DOI: 10.1021/ed058p228 (accessed 2020-07-21)

58. Anderson, J.L. Chemical instrumentation for the visually handicapped. *J. Chem. Educ.,* **1982**, *59* (10)*,* 871–872. DOI: 10.1021/ed059p871 (accessed 2020-07-21)

59. Minkara, M. Accessible Science: Tools for Making Your Science More Accessible. *Canadian Chemistry Conference, Diversity and Innovation in Chemistry*, Calgary, Canada, June 2022.

60. Blind Scientist Tools. *Mona Minkara.* https://monaminkara.com/blind-scientist-tools/#gsc.tab=0 (accessed 2020-07-21)

61. Bennett, C.L.; Brady, E., and Branham, S.M. Interdependence as a Frame for Assistive Technology Research and Design. In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '18)*. Association for Computing Machinery, 2018; pp 161–173. DOI: 10.1145/3234695.3236348 (accessed 2020-07-21)

62. Lounnas, V.; Wedler, H.B.; Newman, T.; Shaftenaar, G.; Harrison, J.G.; Nepomuceno, G.; Pemberton, R.; Tantillo, D.J.; Vriend, G. Visually impaired researchers get their hands on quantum chemistry: application to a computational study on the isomerization of a sterol. *J. Comput. Aided Mol. Des.* **2014**, *28*, 1057-1067. DOI: 10.1007/s10822-014-9782-7 (accessed 2020-07-21)

63. *Working Chemists with Disabilities: Expanding Opportunities in Science*; Blumenkopf, T. A., et al., Eds.; American Chemical Society Committee on Chemists with Disabilities, American Chemical Society: Washington, DC, 1996.

64. Seeing AI in new languages. *Microsoft.* https://www.microsoft.com/en-us/ai/seeing-ai (accessed 2020-07-21)

65. Alt Text. *MOZ.* https://moz.com/learn/seo/alt-text (accessed 2020-07-21)

66. Fluorescent Green Colored Keyboard Stickers. *Amazon.* https://www.amazon.com/Fluorescent-Keyboard-Stickers-Commercial-Impaired/dp/B079GFYMNF/ref=pd_lpo_2?pd_rd_i=B079GFYMNF&amp&psc=1 (accessed 2020-07-21)

67. Magnification. *Paths to Literacy.* https://www.pathstoliteracy.org/magnification/ (accessed 2020-07-21)

68. Low Vision Solutions. *Freedom Scientific.* https://www.freedomscientific.com/products/lowvision/ (accessed 2020-07-21)

69. Dictate your documents in Word. *Microsoft Support.* https://support.microsoft.com/en-us/office/dictate-your-documents-in-word-3876e05f-3fcc-418f-b8ab-db7ce0d11d3c (accessed 2020-07-21)

70. Type with your voice. *Google Docs Editors Help.* https://support.google.com/docs/answer/4492226?hl=en (accessed 2020-07-21)

71. macOS User Guide: Dictate messages and documents on Mac. *Apple Support.* https://support.apple.com/guide/mac-help/use-dictation-mh40584/mac (accessed 2020-07-21)

72. Dragon Speech Recognition Solutions. *Nuance.* https://www.nuance.com/dragon.html (accessed 2020-07-21)

73. Vermeij, G.J. Readers, Braille, and Independence: A Scientist's Perspective. *Braille Monitor*, October 2012. https://nfb.org/sites/default/files/images/nfb/publications/bm/bm12/bm1209/bm120903.htm (accessed 2020-07-21)

74. *HumanWare.* https://store.humanware.com/int/braille-devices/braille-notetakers# (accessed 2020-07-21)

75. Calnan, J.; Muise, D.; Stegeman, J. Advancing Chemistry with 3D Printed Tools. Qualifying Project Report: Worcester Polytechnic Institute, 2018. https://digital.wpi.edu/downloads/ms35t887 (accessed 2020-07-21)

76. Baumer, K.M.; Lopez, J.J.; Naidu, S.V.; Rajendran, S.; Iglesias, M.A.; Carleton, K.M.; Eisenmann, C.J.; Carter, L.R.; Shaw, B.F. Visualizing 3D imagery bymouth using

candy-like models. *Sci. Adv.* **2021**, *7* (22), eabh0691. https://www.science.org/doi/10.1126/sciadv.abh0691 (accessed 2020-07-21)

77. Calculator Options for Individuals with Visual Impairments. *Texas Instruments.* https://education.ti.com/en/product-resources/special-needs (accessed 2020-07-21)

78. Safety Goggles: UV Flex Seal. *Honeywell*. https://sps.honeywell.com/us/en/products/safety/head-eye-and-face-protection/safety-goggles/uvex-flex-seal (accessed 2020-07-21)

79. Braille Authority of North America. *The Use of the Braille Slate and Stylus.* https://www.brailleauthority.org/slatestylus/slate.pdf (accessed 2020-07-21)

Chapter 8: Students Who Are Deaf or Hard of Hearing

Annemarie D. Ross,[1] Thomastine A. Sarchet-Maher,[2] Kevin L. Kelly,*[,3] and Todd Pagano*[,1]

[1]Department of Science & Mathematics, Rochester Institute of Technology/National Technical Institute for the Deaf, Rochester, NY 14623
[2]Center for International Educational Outreach, Rochester Institute of Technology/National Technical Institute for the Deaf, Rochester, NY 14623
[3]Bureau of Reclamation, Denver Federal Center, Bldg 56, Room 1430, Denver, CO 80225

***Email: kkelly@usbr.gov**

***Email: tepnts@rit.edu**

Chapter 8 Contents

8.1 Introduction
8.2 Range of Needs
8.3 Accessibility Guidelines
8.4 Classroom Considerations
8.5 Testing and Evaluation
8.6 Laboratory Considerations
8.7 Assistive Technology
8.8 Conclusion
8.9 References

8.1 Introduction

Students who are Deaf or hard-of-hearing (DHH) can, and often do, find success in the learning of chemistry. There are some best practices and educational design features for implementation in the chemistry classroom and laboratory settings that educators can use as drivers for student success, as well as accommodations and assistive technology that should be considered. Instructors will find that these implementations help not only the students who are DHH but also all students in the learning environment. For example, instructors are encouraged to speak clearly and at a moderate pace, face the class, and avoid introducing excessive new jargon (without first taking the time to explain the new terminology) — to list but a few examples that help students from all backgrounds in the classroom.

Like their hearing peers, students in high school and college who are DHH value teachers who have extensive disciplinary expertise and knowledge of course material, use visual materials, present course content in an organized manner, provide clear explanations, and are friendly and caring.[1–3] Active participation in classroom activities, such as asking and answering

questions and being involved in group work and active learning exercises, is just as important for students who are DHH as it is for their hearing peers. Indeed, participatory learning means higher academic achievement for students who are DHH as well as hearing students, and instructors should consider using more active-learning opportunities.[3,4]

Individuals who are DHH have a variety of communication styles and use a variety of access services. With proper course planning and support resources, they can be very successful in the chemistry classroom and laboratory (and in the future professional workplace). This chapter is written broadly as it relates to age/grade of the students as well as the type of classroom (mainstream or sections composed entirely of students who are DHH). It represents an overview, and readers are encouraged to consult the literature in any one mentioned area for more information and current advancements. Also, it is advisable to reach out to others who have worked with students who are DHH but, more importantly, work in conjunction with the student, solicit their feedback, and address their needs and preferences.

8.2 Range of Needs

Students who are DHH represent a diverse population and, in turn, present a wide range of needs for classroom access and support.[5] Approximately 13% of people aged 12 and older have some degree of hearing loss.[6] Some students who are DHH consider themselves part of a cultural and linguistic group, while others do not consider deafness a part of their identity.[7] Across this spectrum of DHH identities, some people prefer to use a signed language or multiple signed languages as their primary language(s). In other situations, spoken languages and/or a combination of sign and spoken language use is preferred. This language diversity emerges frequently in various educational environments and, in some contexts, may be described as “translanguaging.”[8] These language choices are separate and distinct from the audiological hearing profiles of students who are DHH, and these profiles can range from mild to severe hearing loss.

In addition to different language and modality choices, students who are DHH may use assistive technologies to support visual, tactile, and auditory input (including students who have cochlear implants or hearing aids that are designed to produce useful audio signals). Furthermore, some students who are DHH describe themselves as “DeafPlus,” meaning they have other multicultural and disability identities.[9] These additional identities include blindness or low vision, autism, learning disabilities, intellectual disabilities, and/or physical disabilities. The range of need among each of these groups varies and is described in other sections of this volume. It should be noted, however, that in many situations students who identify as DeafPlus present unique language and communication needs that may not be a consideration among other disability groups.[10,11] As a result of the diversity and variability among students who are DHH, the principles for the diversity of instructional materials and teaching approaches need to be flexible and easily adaptable to the significant range of needs within this population.

Students who are DHH may identify as part of a strong culture (which is why the authors use capital letters in the acronym). For many who identify as culturally Deaf, deafness is often not perceived as a disability. The DHH authors of this chapter identify with the ”DHH” acronym; however, there is no one single universally agreed upon form or usage of these acronyms. Furthermore, some in the culture prefer the use of identity-first (as opposed to person-first) language. There is a variety of opinions on this, and it is often best to ask the student for their preferences. Instructors are encouraged to seek resources for more detailed discussion of Deaf identities.

8.3 Accessibility Guidelines

One of the overarching principles of accommodating individual students' needs is applying the concept of universal design. Keeping universal design at the forefront of class planning is strongly encouraged and is a common theme of this book (universal design is discussed in more detail in Chapter 4). A component of universal design is providing students with class material in different formats and teaching with a variety of modalities. One popular modality is to incorporate videos from various websites. While there is an abundance of excellent materials available, instructors should keep in mind that not all content is captioned (or captioned correctly). It is important that closed or open captioning accompany audio clips or video content that involves speech or other sounds/audio cues. Under the umbrella of universal design, this is done proactively in the design phase of the course or lesson to benefit all in the class, whether an accommodation request has been made or not. Beyond universal design, an expanded conceptual framework of accessibility for the postsecondary education of students who are DHH has been proposed.[12]

Instructors should provide materials in a straightforward, easy-to-follow language. This is especially true for complex, hands-on procedures. As discussed, each student who is DHH perhaps not only has different language and communication needs but also may have an additional physical or learning disability that requires other classroom accommodations. A student who is DHH-low vision may benefit from an up-close monitor that enlarges print and electronic lecture materials. Students who are DHH with learning disabilities may benefit from pre-recorded lectures and laboratory demonstrations so that they can review materials multiple times independently. In addition, modifying the physical classroom or laboratory layout to improve the students' ability to see who is signing or speaking during discussions can help students navigate different stations around the room. Different classroom and laboratory configurations can also improve overall student engagement.[13] These accommodations are detailed with other best practices in the following chapter sections.

8.4 Classroom Considerations

There are several classroom considerations and best practices that can be employed in the chemistry classroom to enhance the learning experiences of students who are DHH. Some considerations are relatively easy to incorporate, while others require some planning and financial support. For example, a simple thing that can be done in a classroom (if safe at that

moment in time) is to flash the lights to gather everyone's attention. Hearing peers will pay attention to flashing lights as well, so this can be a simple and inclusive technique. Again, it is important to note that these best practices tend to make for a better learning environment for every student in the classroom.

8.4.1 Classroom Setup

As do many other students with different learning preferences, students who are DHH depend heavily on visual cues to follow classroom presentations. Consideration should be given to suitable seating positions in the classroom for students who are DHH (like at the front of the classroom). This is done to optimize the student's viewing of the instructor and presentation board. Further, students who use a sign language, low-vision sign language, or oral interpreter must also have a clear view and preferential proximity to the interpreter. Many students who are DHH prefer captioning, in which a provider keyboards spoken words for display on a screen or computer monitor. In each instance, a good line of sight is essential. Captioning is useful for other learning disabilities and even for students who may have just misheard or misunderstood something that has been said.

The lighting in a classroom is very important. All students, of course, need adequate light to take notes during visual presentations. This is balanced with lighting that is optimal for seeing the instructor, teaching board, and any projections on a screen. An additional consideration is for students who are DHH being able to see interpreters and captioning output. When showing videos, slides, or other visual materials that normally require a darkened room, instructors should maintain enough light so that students can still see the instructor and interpreter. Unfortunately, some older classrooms often have poorly designed lighting systems and may require modifications to ensure adequate light. For instance, the installation of a dimmer switch may allow the instructor to maintain enough light during projected presentations. Further, a separate "spotlight" can ensure that the instructor or interpreter is visible in a darkened room.

8.4.2 Line of Sight

Instructors should keep their faces fully visible to the class when presenting. A common oversight occurs when pointing to projections on a screen or other visuals. When doing so, it is important to avoid speaking with the head turned away from the class. Instead, turn the head briefly to refer to the visual, and then turn back to the class to discuss the content in order to improve line of sight for the students. When presenting material on teaching boards, the instructor should write first and then discuss the material while facing the class. Again, breaking the habit of "talking to" the screen or teaching board can be quite difficult. However, like all students, those who are DHH are concerned about missing portions of a lecture (or incidental comments/learning). Another common miscue, which may seem trivial but can impact students' ability to follow a lecture, is when using a laser pointer, mouse cursor, or physical pointing device to point to something on the presentation board, but it is not kept steady (and/or not held in place for long enough) for the students to see both the instructor and the object to which at is being pointed. This can be additionally challenging to a student

who might be experiencing a slight delay as a result of depending on an interpreter or captioning provider.

A student who is DHH can miss information that might be generated by a peer who is sitting behind them in the classroom. When possible, classroom seating should be arranged so that all students can see each other. Seats positioned in a U-shape or semicircle allow for the best visibility for all students. In spaces where such a setting is not possible, it is important that the instructor facilitate communication. Students who wish to speak or ask questions can come to the front of the room to do so. Otherwise, the instructor should repeat questions or comments that come from the students in the classroom (more on this below).

8.4.3 Pace

The wealth of curriculum needed to cover, time spent with classroom management, and other daily time constraints can often compel instructors to teach at a quicker pace than they would otherwise prefer. Pauses during classroom presentations can be useful for all students, and especially helpful for students who are DHH. Students must often coordinate multiple tasks at the same time — watching the instructor while simultaneously taking notes; reading written material on overheads or presentation boards; or watching a demonstration, film, or video. Some students do all of this while also following an interpreter or captions. A potential problem arises because many students who are DHH receive and process only visual information, instead of visual information supplemented by auditory cues. A student who looks down to a computer keyboard for a few seconds may miss critical information from the instructor or interpreter. A student who is following an interpreter may miss visual cues that help explain the information from the instructor, who may be pointing to a reaction or structure on a screen or presentation board. It is important to emphasize that there is a delay or lag in the information that students receive from an interpreter or through captions (as the support personnel must process and convert the information from the instructor to sign language or text). To compensate for these situations, instructors can maintain a reasonable pace, take pauses, and glance at students periodically to see if the pace is appropriate.

The student's full participation can be greatly enhanced if the instructor pauses occasionally during the presentation so that students can keep pace. Pausing is particularly important in cases in which the student is using only an interpreter or captioning without a note-taker. Again, the interpreter or caption provider needs a few seconds to complete the processing of the lecture material before they relay the information to the student. The instructor can help by recognizing the existence of such time lags and incorporating regular pauses.

8.4.4 Note-Takers and Class Transcripts

As mentioned, students who are DHH have to track a considerable amount of information input. They may be following the instructor, reading a teaching board, and watching the interpreter/captioning output—and do all of this nearly simultaneously. Should the student also be taking written or electronic notes, they would miss a considerable amount of the sources of

information input. Therefore, it is a best practice to provide note-takers for the students. The instructor should review these notes for accuracy and thoroughness after the class and promptly distribute them to the student who is DHH. Likewise, if a captionist is available for the class, the resulting transcripts can be given to the student as “class notes” (in printed or electronic form).

It is important to take into consideration who is chosen as the note-taker. A note-taker could be a former student from that class or an additional support professional, but should be given some training so that they capture quality and accurate notes. Previous students who have succeeded in that course are particularly good candidates. Someone who has a background in the content area is an important consideration, as they can emphasize/notice some of the nuances that a general note-taker may overlook. Some caution should be used related to the instructor giving their own notes, which is often greatly appreciated, but the notes are not always representative of everything that was exactly covered/pointed out as the class session unfolded. A note-taker is still necessary to capture those important teaching moments. If logistical limitations dictate it, a current student in the class could assume the role of the note-taker, but providing training to the note-taker and reviewing the produced notes are important.

8.4.5 Repeat Questions/Comments from the Class and “Wait Time”

When comments, questions, or conversations come from other students in the classroom, and particularly from students in the back of the room (or out of their line of sight), a student who is DHH might not know from where the comment is originating or might miss it altogether. They might also not know which questions have already been addressed—a fact that makes many students who are DHH reluctant to ask questions and become involved in classroom interaction.

The instructor can respond to these situations by repeating questions asked by other students: "The question was..." This repetition also is helpful for hearing students who may have missed or misunderstood the question. During discussion sessions, the instructor can help by controlling the pace of the discussion and encouraging only one student to respond at a time. Again, this level of turn-taking should benefit all students in the classroom environment. Instructors also may consider summarizing classroom discussion at logical points in each lecture.

Additionally, instructors should pause for a few seconds after asking a question during group discussions. This “wait time” enables students who are DHH to more fully participate in lectures. Wait time allows students to “catch up” from reading the captions or watching the interpreter and an equal opportunity to share their answers with the class.

8.4.6 Scientific Discourse and Terminology

It is not always possible to have interpreters in chemistry classrooms and laboratories that have deep knowledge of the subject material and experience in converting advanced scientific concepts and terms into signs. In fact, seldom do interpreters or caption providers have a background in chemistry. Instructors should be aware that many scientific terms have no specific counterparts in sign language. That is especially common in new or rapidly evolving scientific fields in which terms are constantly being coined. In these situations, the interpreter will usually finger-spell the word. There are resources available for both the instructor and interpreters to find some signs for scientific terminology. Such resources include ASL CORE[14] and the ASL Video Dictionary and Inflection Guide.[15]

The instructor can help by writing new terms on the teaching board. A brief written definition, or clearly stated oral definition, is also helpful in accompanying the term. It is good practice to alert the student, interpreter, or caption provider in advance of any presentation that might include a great deal of new terminology. If possible, provide the vocabulary in advance, or suggest textbook pages or other references that can assist the student and support personnel. This will allow the interpreter time to research the concepts (and the caption provider the opportunity to familiarize themselves with the terms). The student and the interpreter sometimes work together in advance to agree on signs for new terminology, acronyms for the terms, or abbreviations. However, it is also a common and accepted practice for the student and the interpreter to develop and agree on new sign vocabulary "on the fly" in the classroom. In either case, it is important to recognize that any agreed upon sign for a term in a specific class would not necessarily be understood/used by others outside of that class. A couple of resources for scientific sign language exist.[14–17] In addition to emphasizing vocabulary, it is important to provide plenty of opportunities to use technical vocabulary with everyday language. For example, the use of scientific argumentation provides an opportunity to persuade using technical vocabulary, while practicing a necessary skill for scientists (i.e., scientific argumentation using evidence).[18,19]

8.4.7 Remote/Online Education

Instructors and students have become more familiar with online education, using platforms such as Zoom, and some best practices have been discussed for teaching chemistry to students who are DHH.[20] The built-in chat function on online learning platforms can supplement content by providing an area to clarify technical vocabulary and items that might require emphasis. The chat feature can also be useful to students in conversing about setting up study sessions or clarification of concepts through peer-to-peer interactions. Annotating on Zoom screens can also be useful, although it must be kept in mind that students who are DHH might have to follow multiple screens, including one with a sign language interpreter, and may need extra time to catch up on what has been recently annotated. Most of these features, including automated live transcription through Automated Speech Recognition (ASR), are provided in other platforms as well, like Microsoft Teams. It should be noted that a problem with the ASR is that it can have a lot of errors especially when nonstandard or technical

vocabulary is used. As remote teaching becomes more integrated, improved features/software may be developed that is increasingly visually friendly for students who have to look at multiple screens simultaneously.

8.4.8 From Students' Perspectives

Students at the National Technical Institute for the Deaf (NTID)[21] put together a "top ten list" of items to help instructors be more inclusive.[22] The list includes minor changes that can make significant improvements in student success in the classroom. While the list is for general education, all of the items are applicable to the teaching of chemistry.

The student-developed list includes (i) avoiding the use of generic references, like "this" and "that," which can be very confusing for someone whose eyes are on the interpreter, and not where the instructor might be pointing. Laser pointers are used often to point out "this and that," which can move too quickly for students to follow. As mentioned, make sure to (ii) hold the pointer for a little bit longer prior to moving to the next focal point on a visual.

Visuals are used quite frequently in a class setting, and they are important for introducing and clarifying learning concepts. When referencing a visual, (iii) allow students time to quickly scan/read the visual prior to discussing it. In doing so, the student can then have an initial and broad idea about the material to assist their learning process.

Online teaching and course management systems have made another top ten item a bit easier to address: (iv) providing lecture notes and slides prior to class. This enables the student to preview the terminology and content to better prepare for learning during the lecture. It makes the process less overwhelming, as the student who is DHH experiences the interpretation process in addition to learning the new content. This course material that is available prior to the class should also be shared with support services (interpreters, caption providers, note-takers, etc.) to help them improve their familiarity with the content prior to class sessions.

It is worth noting that a lot of the top ten list refers to supporting the learning process of the student. As touched upon, "process time" is also an important concept, as there is lag time, or a delay, when a sign language interpreter is transposing from one language to another; or an access service provider (like a caption provider) is presenting the material from one form to another. As these adjustments are made, (v) allowing time for the delay gives the student the time needed to adjust and respond appropriately. If a student needs to respond through the use of an interpreter, it is important to remember that (vi) the interpreter is not always an entirely accurate reflection of the student. While interpreters are often very skilled in sign language, errors can be made (and can be compounded when the course content is very technical and utilizes a lot of finely differentiated terminology, and instructional pacing is too fast) — so following up with clarifying questions to the student can ensure that the response is understood.

As previously mentioned, (vii) providing students with space at the front (or optimal area) of the room is important so that students have minimal interference in their sight lines. The student should be able to move from one visual focus, like the interpreter, to another easily and without obstructions.

Overall, a (viii) positive/flexible attitude is vital to ensure students feel comfortable and supported in the classroom. Provided that the instructor is willing to set up an inclusive environment, the students will feel that they are treated equally—and this is another item from the top ten list. When students feel that they are (ix) treated equally to their peers, they will engage more efficiently in the learning process. One way to accomplish this is to (x) not always force the students in the class who are DHH to work together or alone when group work is being conducted. It is important to check in with the students and their comfort level in group assignments. The number of available interpreters and caption providers can be limited in the classroom, so it can take some planning to ensure that group work is conducted effectively.

8.5 Testing and Evaluation

Students who are DHH generally take the same written examinations administered to the rest of the class. To understand oral instructions, however, they will require the same accommodations used during regular classroom sessions. Students might also request to take quizzes and exams at a central supervised testing center. Moreover, students who are DHH or DeafPlus may need extended time to complete these assessments. In preparation for graded events, supported office hours and tutoring sessions should be provided to the extent possible. Instructors should also ensure they have received information on all of the appropriate examination accommodations required for students to be assessed fairly.

It is important to note that English can be a second language for some students who are DHH because they might have been raised using American Sign Language (ASL) as their home language (or some other spoken or country-specific sign language), just like any other English-as-a-second language learner. ASL was not officially documented as its own language with its own syntax and grammar until 1965;[23] thus, it is easy to forget that some students who are DHH are second language learners. As is often the case in a multicultural classroom, students' levels of learning cannot always be measured by their ability to read and express themselves in written English. Therefore, when designing and grading written tests/assignments, care must be taken to distinguish the students' grasp of the subject matter from potential gaps in English language skills. Also keep in mind, if the class is taken with an interpreter, the content may have been conveyed in ASL (not in English) which can also have an impact on student expression.

8.5.1 Homework and Lab Assignments

As mentioned, students who are DHH may be second-language learners. Therefore, it is important to keep their language backgrounds in mind as the homework and labs are

developed and evaluated. For instance, a student may not have understood the original question as they answered it, but if the question was signed, then they might be able to answer it far more adequately. Consider alternative assignments, such as allowing the student to provide answers via sign language, through video.

If laboratory reports are required to be submitted by the students, consider allowing revisions so that students are given a chance to express their understanding through improved iterations of their written reports. Such an approach supports that the student is graded based on their understanding of the laboratory concepts and not limited by their written English expression.

8.5.2 Graded Presentations

Allowing students to present in their first language is helpful so that the content is assessed as a truer metric of their understanding of the material. Allowing time before the presentation for the student to work with the interpreter will help to ensure that less information is missed through the interpreting process. A grading rubric is encouraged as well, since it not only provides the students with a guide as to the instructor's expectations but also provides an opportunity for dialogue to better understand the requirements. Students who are DHH may also need to work with their classroom interpreter to ensure their presentations are voiced correctly.

8.6 Laboratory Considerations

Students who are DHH may need accommodations in the laboratory setting but should be fully able to participate in the experiments. Many of the classroom considerations previously mentioned apply in the academic laboratory as well. For example, the laboratory instructor should pause frequently during any laboratory demonstration so that all students have ample time to complete multiple visual tasks. Those tasks can include watching lab demonstrations and the interpreter/caption provider while taking notes. In practice, students who are DHH should be able to readily participate in the academic laboratory with a few considerations and best practices.

8.6.1 Effective Communication

Good communication includes making sure that the student who is DHH receives and understands all verbal instructions for laboratory procedures (this is especially vital for safety related information), along with any announcements or modifications to the laboratory procedures. It is important that access service personnel (interpreters, caption providers, etc.) are also kept in the communication loop. A "dry run" of the experiment can be demonstrated to visually support the written instructions. Particular attention should be paid to incidental learning moments (where a student might benefit from communication that might otherwise not be shared with the entire class—and troubleshooting a laboratory experiment with one group of students is a prime example of learning that would benefit other onlooking groups of students).

Facilitating communication is an important role of any instructor. It is important to ensure that turn-taking is occurring when students are communicating (and that only one individual in the classroom is speaking/presenting at any one time). Instructors should be open to learning from their students, not only about their class needs but also about their culture and language. Students are generally more than happy to teach instructors and peers new signs, including those that might be important in the laboratory setting.

8.6.2 Safety, Personal Protective Equipment, and Emergency Alarm Systems

Clear and accurate communication is especially vital when addressing safety concerns. Instructors, access service personnel, and students should work together and prepare in advance for potential emergency situations. Personal protective equipment (PPE) should be worn by all (including support personnel), and feedback from the students should be sought to make sure that the PPE is comfortable with hearing aids, cochlear implants, etc. An often-overlooked hazard can occur when an individual who is signing and has been using chemicals, brings their safety-gloved hands to their face or body (as is often done when communicating in sign language). Signing in this way is second nature, but it can be problematic if their gloves are contaminated with a chemical (that is subsequently transferred to them when signing).

Emergency warning alarms, like fire alarms, should also include a visual indicator, preferably with flashing lights, and should be visible from all areas of the lab. Likewise, emergency evacuation routes should be clearly posted and discussed prior to the conduct of the first experiment.

8.6.3 Unobstructed Views

Interpreters should sign near an instructor-led demonstration to minimize the need for the student to continually look back and forth between the demonstration and the interpreter. In these instances, the interpreter should wear appropriate personal protective equipment. As an aside, finding an interpreter can seem like a daunting task. Agencies that provide sign language interpreters vary by state, but in working with your disabilities support office, a starting point could be the National Registry of Interpreters for the Deaf (RID).[24] Students should have lab stations with an unobstructed view of the instructor, interpreter, and captioning screen. In general, a clean and organized lab (without a lot of obstructions) is good safety hygiene for everyone in the lab environment.

8.6.4 Visual Indicators

Visual cues on equipment are necessary to supplement audible information, indicators, and sounds that indicate whether equipment is on, off, or awaiting a prompt. Most current and well-designed equipment already have visual status indicators, such as glowing LEDs or lights, but a few that do not could still be around. Some older equipment can be monitored by touch. For example, a mechanical timer with a metal bell produces enough vibration to be felt when it goes off. However, newer electronic instruments, such as an electronic timer that beeps, cannot be detected by vibration. It is important that this type of equipment, like the

previously discussed emergency alarms, also have visual indicators (e.g., when a software "start" button changes from bold to italicized after an analytical run is completed).

8.6.5 Group Work/Partners

Lab instructors should remember that students who are DHH want to participate in lab experiments as their peers do. When assigning a collaborative exercise or laboratory, instructors should work with the student to find a comfortable group setting. While interpreter and captioning resources can be limited, instructors should avoid always grouping the students who are DHH in the same group.

8.6.6 New and Future Apps

New tools and apps for accessibility are becoming available at a rapid pace. For example, there are apps that alert students and scientists to sounds in the work environment by vibrating and flashing on their smartphones. The sounds could be of safety concern (alarms, crashes, etc.) or could be an instrument informing the scientist that a run is complete, for example. Students are often familiar with helpful apps, and instructors are encouraged to work collaboratively with the students to discover and figure out ways to implement these technologies (that will undoubtedly multiply in the future).

8.7 Assistive Technology

Assistive technologies that support the learning of students who are DHH have come a long way over the years, and living in a technological-driven world has contributed to accessibility. This has been realized in both positive and negative ways; while remote video interpreting, for example, has been very beneficial, smartphones for use with audio in-person conversations has been limiting to some. The future may provide even more accessible accommodations. ASR technology has the potential to provide real-time, speech-to-text transcription of a lecture, though the accuracy of the technology is still improving (and should only be fully considered when the technology is at an appropriate point in its development). Some assistive technologies for consideration in the classroom or teaching laboratory environment are discussed below. Students work in conjunction with their audiologists related to their personal hearing aids or cochlear implants (or whether they do not use any aid at all). Due to the personal preferences, changing technologies, and variety of options, these are not specifically discussed in this chapter.

8.7.1 Assistive Listening Devices

Students who wear a hearing aid may request that the instructor use a microphone compatible with an assistive technology called a FM (frequency modulation) loop system. FM systems are wireless assistive devices used to transmit sound providing a direct connection between student and teacher. In this system, sounds are transmitted by FM radio waves directly to a hearing aid. This results in greater sound clarity, as it significantly reduces background noise and can improve comprehension for some users. An FM system can be used with many types

of microphones, which may be provided by the student or Disability Services Office. These include a transmitting clip-on microphone worn by the instructor, a tabletop omnidirectional microphone designed to pick up a group discussion, or microphone on a lanyard that is given to the person who is presenting.

8.7.2 Captioning/Interpreting

Instructors may also encounter other important forms of assistive technology for students who are DHH—Communication Access Realtime Translation (CART), as well as C-Print® and TypeWell (other real-time captioning access services). Each of these services provides different forms of text information presented in the classroom. CART involves a service provider creating a verbatim transcript of the class as it occurs in real time. Due to capturing verbatim voicing, during the course of a class session, a CART transcript can become quite long (and sometimes challenging for a student to get through if they are using the transcript after class). Similar to CART, C-Print® and TypeWell use an access service provider to generate a transcript in real time. The transcript produced, however, is a meaning-to-meaning condensed translation of classroom information.[25] These transcripts can be easier for students to work through when using the transcript after a class. However, students have preferences as to which type of captioning they prefer in an educational setting. C-Print®, TypeWell, and CART involve specially trained providers who type classroom discourse as it occurs. The text appears on a second laptop, monitor, or screen for viewing by the student. The service providers may also provide the student with printed notes or an electronic file of the transcripts. CART, C-Print®, and TypeWell providers can be present in the classroom or can be working remotely by listening to the lecture over a phone line or computer audio. Finally, another form of captioning, open or closed captioning, transcribes audio into text format through an overlay on the video and can be done through a decoder.

Sign language interpreters can be provided in-person or through online video platforms, such as Zoom, using Video Remote Interpreting (VRI). VRI is an online supported technology that displays an interpreter on a screen/monitor for students in the classroom. This allows students who are DHH to engage in dialogue through the use of the remote interpreter. Some students who are DHH may prefer in-person interpreters, as body language and visual cues can be more easily communicated off-screen.

As mentioned, ASR is a promising technology for text captioning of classes. While the technology, which can be assisted by artificial intelligence, is advancing, it is important to keep in mind that the accuracy of the text-to-speech capture is not necessarily where it needs to be (at least not at press time). There are different times/situations when the technology can be currently used, but for student learning of important concepts, complete accuracy is a must (so that the student doesn’t miss out on any information). In a lecture setting, ASR is also a one-way mode of communication, where, without an interpreter, some students who are DHH might not be able to ask questions or otherwise be able to interact in the class. Still, it is worth tracking promising developments in ASR technology for use in the classroom.

ASR is also sometimes used for the captioning of videos or web-based content. Some software and online applications can auto-caption the recorded speech. As above, the auto-captioning is not always entirely accurate. However, most platforms have a mechanism by which the auto-captioned text can be manually modified, edited, and fixed.

Potentially helpful future technologies might be on the horizon. One example might be sign language avatars, where speech/text to signing (or even vice versa) is done on an interactive computer interface. While all of the subtle hand and facial expressions and use of signing spaces are very important in sign language (and currently these are best communicated via a live interpreter), avatars are being researched to use in situations where an interpreter might not be available. While still in development, advances in this field might have some use in educational settings in the future.

8.7.3 Assistive Technology in Online Education

In recent years, online and remote education has seen a substantial uptick in use. Many are now familiar with the use of virtual platforms, like Zoom or Flipgrid, to operate as a classroom environment. Previously mentioned technologies, like VRI and auto-captioning, can accompany online learning. Whether for online or in-person classes, course management systems (Blackboard, Moodle, etc.) have become a regular part of the educational experiences. These management systems should be used regularly with clear announcements/instructions. Further, the posting of course material and notes on the systems helps all students and support personnel to be better prepared for class and have transparent information available to them.

8.7.4 Interpersonal Communication

Just as their peers do, students who are DHH often use smartphones that provide interactive text/chat features, email, FaceTime, and other services. These are the primary forms of communication these days — and text and other computer-based communication methods, including internet chat, social media, and smartphone applications, have become widely available links between individuals.

While far less common today, the TTY is a text telephone, given that acronym because it originated in technology used for teletype machines. Another technology for interpersonal communication is the Video Relay Service (VRS), with the use of an interpreter on screen that is used predominantly for phone conversations. Other technological devices include voice-to-text resources like CapTel,[26] which is a phone specifically designed with a screen to display the words of the person speaking. Displaying text can be done through a third-party listening and typing up the words for the screen, or potentially through ASR.

TTYs used to be a primary tool for telephone conversations for individuals who are DHH, but VRS (and texting/emailing) has all but taken over. Their use requires that both parties in the conversation have a TTY terminal, as is the same with the VRS, which requires both parties to have a VRS account. However, when only one party has a TTY terminal or a VRS account,

telephone conversations can be carried out through the telecommunications relay service (TRS), where interpreters are provided through video with the VRS. Personal computers can call and communicate with a TTY terminal.

ASR can sometimes be used by members of the DHH community when they find themselves without an interpreter. These applications can be downloaded onto an individual's smartphone, for example, and convert voice through the built-in microphone to display the words on the phone screen. One such application is Otter Voice,[27] which is easy to use, but there are also alternatives.[28] An ASR user could initiate a conversation or respond to a comment by typing their response using their phone's keyboard. In some systems, when two phones are linked online, a closed conversation between individuals can be experienced.

It is important to note that errors can occur with the use of any transcription from a technology-based device. ASR, CART, and the like can be inaccurate, as dictionaries within each technology may not include very specific or uncommon terminology. For example, a science term that is not as commonly used by the general population may not be in the dictionaries. Therefore, it is important to look over the transcription for accuracy.

8.8 Conclusion

Students who are DHH can find, and have been finding, success in the chemistry classroom and laboratory at a variety of academic levels. Instructors can assist along the pathway to success by really getting to know the students, their preferences, and situations in which their learning can thrive. No two students are exactly the same, so flexibility and reflection are critical for effective teaching. Attention to classroom and laboratory best practices, accessibility, accommodations, and access technology are necessary in planning the educational experiences. Some students who are DHH will thrive in the learning of chemistry, pursue postsecondary and graduate degrees in the chemical sciences, participate in internships/cooperative work experiences, get involved in chemistry-related research projects,[29,30] and pursue careers in the field.

8.9 References

1. Lang, H.G.; McKee, B.G.; Connor, K. . Characteristics of Effective Teachers: A Descriptive Study of Perceptions of Faculty and Deaf College Students. *Am. Ann. Deaf* **1993**, *138*, 252–259

2. Lang, H.G.; Dowaliby, F.J.; Anderson, H. Critical Teaching Incidents: Recollections of Deaf College Students. *Am. Ann. Deaf* **1994**, *139*, 119–127.

3. Lang, H.G.; Stinson, M.S.; Basile, M.; Kavanagh, F.; Liu, Y. Learning Styles of Deaf College Students and Teaching Behaviors of Their Instructors. *J. Deaf Stud. Deaf Educ.* **1998**, DOI: 10.1080/14790718.2017.13158084, 16–27 (accessed 2020-07-21)

4. *Science Teaching in Inclusive Classrooms: Theory and Foundations and Science Teaching in Inclusive Classrooms: Models and Applications*; Stefanich, G.P., Ed.; Woolverton Printing: Cedar Falls, IA, 2001.

5. Marschark, M.; Hauser, P.C. *How Deaf Children Learn*; Oxford University Press: Oxford, 2012.

6. NIH. *Quick Statistics About Hearing*. https://www.nidcd.nih.gov/health/statistics/quick-statistics-hearing (accessed 2020-07-21)

7. Leigh, I.W. *A Lens on Deaf Identities*; Perspectives on Deafness; Oxford University Press: New York, 2009. DOI: 10.1093/acprof:oso/9780195320664.001.0001 (accessed 2020-07-21)

8. Swanwick, R. Translanguaging, Learning and Teaching in Deaf Education. *Int. J. Multilingualism* **2017**, *14* (3), 233–249. DOI: 10.1080/14790718.2017.1315808 (accessed 2020-07-21)

9. Christensen, K.M. *Deaf Plus: A Multicultural Perspective*; DawnSign Press: San Diego, CA, 2000.

10. Singer, S.J.; Cacciato, K.; Kamenakis, J.; Shapiro, A. Determining Language and Inclusion for Deaf-plus Children. *Int. Electron. J. Elem. Educ*. **2020**, *13* (1), 1–19.

11. Hyte, H.A. Supporting Teachers of Students Who Are Deaf plus: Perceptions in Provision of Supports and Resources. Ph.D. Dissertation, The University of Utah, Salt Lake City, UT, 2017.

12. Cawthon, S.W.; Garberoglio, C.L.; Palmer, J.; Ivanko, T.; Davidson, S.; Ryan, C.; Johnson, P. Accessibility of Postsecondary Education and Training for Deaf Individuals: A Proposed Conceptual Framework. *Future Review,* **2020**.

13. Guardino, C.; Antia, S.D. Modifying the Classroom Environment to Increase Engagement and Decrease Disruption with Students Who Are Deaf or Hard of Hearing. *J. Deaf Stud. Deaf Educ.* **2012**, *14* (4), 518–533. DOI: 10.1093/deafed/ens026 (accessed 2020-07-21)

14. ASLCORE. https://aslcore.org/ (accessed 2020-07-21)

15. *NTID ASL Video Dictionary and Inflection Guide*. https://www.rit.edu/ntid/dictionary/ (accessed 2020-07-21)

16. *NTID DeafTec STEM Dictionary*. https://deaftec.org/stem-dictionary/dictionary_term/abiotic/ (accessed 2020-07-21)

17. Caccamise, F.; Lang, H.G. *Signs for Science and Mathematics: A Resource Book for Teachers and Students*; National Technical Institute for the Deaf: Rochester, NY, 1996.

18. Ross, A.D.; Yerrick, R.; Pagano, T. Examining the Use of Scientific Argumentation Strategies in Deaf and Hard-of-Hearing Learning Contexts to Teach Climate Science. In *Communication in Chemistry*; Crawford, G.L., Kloepper, K.D., Meyers, J.J., Singiser, R.H., Series Eds.; ACS Symposium Series; American Chemical Society: Washington, DC, 2019; pp 75–95.

19. Ross, A.D.; Yerrick, R.; Pagano, T. Use of Scientific Argumentation by Deaf and Hard-of-Hearing Students in Environmental Science Topics. *J. Sci. Educ. Stud. Disabil.* **2020**, *23*, 1–26.

20. Lynn, M.A.; Templeton, D.C.; Ross, A.D.; Gehret, A.U.; Bida, M.; Sanger, T.J., II; Pagano, T. Successes and Challenges in Teaching Chemistry to Deaf and Hard-of-Hearing Students in the Time of COVID-19. *J. Chem. Educ.* **2020**, *97* (9), 3322–3326. DOI: 10.1021/acs.jchemed.0c00602 (accessed 2020-07-21)

21. *National Technical Institute for the Deaf* | *RIT Home Page*. https://www.rit.edu/ntid/ (accessed 2020-07-21)

22. Top Ten Things D/HH Students Would Like Teachers To Do. *DeafTEC*. https://deaftec.org/teaching-learning/best-practices-for-teaching/top-ten-things-d-hh-students-would-like-teachers-to-do/ (accessed 2020-07-21)

23. Stokoe, W.C. *Dictionary of American Sign Language on Linguistic Principles*; Gallaudet University Press: Washington, DC, 1965.

24. RID. *Resources for the Consumer and the interpreter*. https://rid.org/about/resources/ (accessed 2020-07-21)

25. Stafford-Mallis, V. Demystifying Speech to Text Services: CART, C-Print, and TypeWell. *Hands & Voices* 4.

26. *Captioned Telephones for Hearing Loss* | *CapTel Captioned Telephones*. https://www.captel.com/ (accessed 2020-07-21)

27. Otter.ai. *Voice Meeting Notes & Real-time Transcription.* https://otter.ai/ (accessed 2020-07-21)

28. *Otter.ai Alternatives.* https://sourceforge.net/software/product/Otter.ai/alternatives (accessed 2020-07-21)

29. Pagano, T.; Ross, A.; Smith, S.B. Undergraduate Research Involving Deaf and Hard-of-Hearing Students in Interdisciplinary Science Projects. *Educ. Sci.* **2015**, *5* (2), 146–165. DOI: 10.3390/educsci5020146 (accessed 2020-07-21)

30. Pagano, T.; Bida, M.; Ross, A.D.; Pagano, S.S. Accessibility in Undergraduate Research Experiences: A Novel CURE. *Scholarship Pract. Undergrad. Res.* **2021**, *4* (3), 3–4.

Chapter 9: Communication Impairments

Stephanie A Hall*[,1] and Kathleen H. Palatucci*[,2]
[1] Infinity High School, Science and Special Education, Belen NM 87002
[2] President, New Jersey Speech-Language-Hearing Association, 174 Nassau St, Suite 337, Princeton, NJ 08542

***Email: seananf@gmail.com**
***Email: kathy4njsha@gmail.com**

Chapter 9 Contents

9.1 Range of Needs
9.2 Accessibility Guidelines
9.3 Classroom Considerations/Adaptations
9.4 Testing
9.5 Laboratory Considerations/Adaptations
9.6 Assistive Technology
9.7 Considerations for Distance Learning
9.8 Summary
9.9 References and Resources

9.1 Range of Needs

Communication impairments occur as speech sound disorders, spoken language disorders, or both.[1] Both speech sound disorders and spoken language disorders impact the individual along a continuum from mild to severe impairment which affects communication across speaking contexts. Mild impairment may impact speakers in profound ways as there may be reluctance on the part of the student to participate in class discussions or provide oral presentations.[1]

A speech sound disorder may be organic or acquired. It may be due to a neurological injury (e.g., cerebral palsy, traumatic brain injury, cleft palate, stroke) which affects the structures of the oral cavity, or the innervation and fine motor planning required for speech production. Additionally, the etiology of the speech disorder may be unknown.

Examples of speech sound disorders include dysarthria, misarticulations, speech sound distortions, and fluency disorders such as stuttering or cluttering.

> Dysarthria: Speech production is distorted due to weakness of the oral muscles, imprecise contacts of the articulators, and/or delayed fine motor coordination. This is often referred to as slurred speech which is not to be confused with inebriated speech.

Misarticulation: Occurs when a speech sound is produced in error such as a lisp or substitutions of one speech sound for another speech sound. It is important to note that these differences in speech sound production are not confused with regional dialects or accents associated with non-native English speakers.

Speech sound distortions: The sound is correct in terms of placement, but the production is atypical; this is often related to the coarticulation of the consonant with the vowel. An example of speech sound distortion is often associated with deaf and hard-of-hearing individuals. Another possibility is the speaker may have had speech therapy to address the error production but the error has not been resolved. It is important to note that distortion of speech sounds may not interfere with speech intelligibility or oral communication. A difference in production may however impact the speaker's desire to speak depending on the social context.

Fluency disorders: Stuttering is the most common form of fluency disorder and is characterized as an interruption in the smooth production of speech. This may be heard as the repetition of beginning word sounds or syllables, blocking, or prolongation of sounds to name a few. The speaker may find speaking aloud to be difficult and may hesitate to participate.[2]

Cluttering presents as a fluency disorder which is different from stuttering. It may include a rapid or irregular speech rate, syllable omission, and decreased awareness of communication breakdowns. Cluttering may be associated with other disorders such as learning disabilities, auditory processing disorders, autism, Attention Deficit Hyperactivity Disorder (ADHD), and others.[2] Additional resources are provided to inform educators regarding best practices for working with individuals who stutter.[3,4]

A Spoken Language Disorder, or oral language disorder, is an impairment due to deficits in the ability to produce oral language or comprehend spoken language. The components affected include word retrieval difficulty, decreased organization, impaired syntax, and pragmatic expressions. Spoken Language Disorders may co-occur in individuals with learning disabilities, intellectual disabilities, developmental disabilities, traumatic brain injury, autism, ADHD, psychological/emotional disorders, or hearing loss.[5]

A Written Language Disorder may be a problem with reading and comprehending written language or a problem with writing. Academic writing requires the ability to use correct spelling and syntax as well as the ability to plan, organize, revise, and edit texts to convey meaning. Referral to a university writing lab may be a way to help a student who is struggling with written assignments.[6]

A Social Communication Disorder may be present when a communication partner has a reduced ability to understand nonverbal communication such as interpretation of facial expressions and or body language, has difficulty with pragmatics and social interaction, or has difficulty with language processing. A Social Communication Disorder ranges in severity and may either be a distinct language disorder or be associated with other conditions such as

Autism Spectrum Disorder. A more detailed description may be found on the ASHA website which is referenced below.[7]

9.2 Accessibility Guidelines

There are many different factors to consider when planning accommodation to provide accessibility in a classroom and lab setting: the type of communication impairment(s) the student has, overall layout of the classroom, acoustics of the environment, types of communication required in the class, and communication levels (one-on-one, small group, large group). It is important to consider the communication requirements of a class, the amount of new and/or complex vocabulary, the amount of receptive vs expressive communication, whether settings for expressive communication are more one-on-one, small group or large group, and the types of language being used: aural, oral, visual, or written. The student's communication abilities and preferences will all play a part in determining the best strategies for ensuring student success.

Students with communication impairments should be allowed to choose seating close to the instructor or to a student or students of their choice that they find easier with whom to communicate. Students should be able to pick group/lab partners based on their ability to successfully communicate with those partners. Students need to be allowed to use alternate forms of communication such as writing out a question or texting vs having to raise a hand and be called on verbally.[7] Students using computers or Augmentative and Alternative Communication (AAC) for text to speech accommodations may require access to charging locations.

9.3 Classroom Considerations/Adaptations

Communication of information from teacher to students, students to teacher, and students to students can all be impacted for students with speech/language disabilities. Students with communication impairments will benefit from a limited sound distracting environment. Extraneous sounds such as from an open window, music playing, multiple groups of people all talking to each other in an area, etc. can make it harder for messages to be sent and received. Whenever possible, there should be a quieter corner available for students to be able to work with classmates in groups and labs.[7] This can be achieved by placing an empty space buffer around the lab station and group location where the student with the speech/language disability will be working.

Vocabulary, especially class specific/specialized vocabulary, can also be a problem for students with speech and language disabilities. There are many complex words that are challenging to both pronounce and recognize/recall in science classrooms. Even students without impairments can have problems with correct pronunciation of chemical names or names of common laboratory equipment. Ways to accommodate these problems can be to use word banks and visual communication alternatives, such as being able to point to types of equipment and chemicals on pictures/posters or in person vs. having to be able to say the complex names. Allowing students to write out what they want to say using technology, personal white boards, or paper/pencil can be very useful. Be sure to consider any other types of disabilities that may be present to ensure students can fully utilize any/all provided

accommodations. The types of accommodations selected should be a joint collaboration between the teacher and the student to ensure a system that works for everyone and allows the student full communication access.[8-10]

Some students may use some form of an assistive communication device. Some examples of different AAC devices can be found at https://www.nwacs.info/learn-about-aac.[11] It will be especially important for people with these types of devices to be provided with lists of vital vocabulary and procedures that will be used in group/laboratory settings to allow them to become familiar with the vocabulary in advance and, if needed, program information into the device. Examples of this could be an electronic communication board used as a speech generating device, alpha-numeric speech generating device, or a tablet/computer that is being used as a speech generating device. In all three types of situations, specific information will be keyed or programmed into the device such that the person can with few movements be able to express pre-recorded messages relevant to the information being communicated in class.[11]

Students with all types and ranges of communication impairments will benefit from having prior knowledge of communication expectations and extended time to process, formulate, and transmit information. Teachers and classmates need to provide a safe communication environment where the student with speech/language impairment is able to have the time and space needed to be able to communicate without others taking over for them, filling in words unless asked, etc. Students need to be included in all aspects of class communication unless they ask to be allowed to be excused or have an alternative option. Alternatives should always cover the same learning goals and be equivalent to the original activity.[8,9]

9.4 Testing

Students with communication impairments may or may not require adaptations or accommodations to complete pen and paper assessments. It is important to consider any other disabilities that might occur along with the communication impairments and be sure those accommodations are in place as well. For practical assessments, determine with the student if speaking is necessary and in what ways the students would be able/comfortable to express their knowledge. If possible, the teacher can simply observe the student complete the activity to determine competency, once again considering any other areas of disability/impairment.

Students with communication impairments, especially ones that have impairments involving expressive/receptive language skills, can benefit from word banks or picture dictionaries. A picture dictionary can be as simple as a laminated sheet of paper with photographs of tools and chemicals that will be used in a lab that day, for example, a page with a picture of a scale, a bunsen burner, a scoop, weighing paper, a graduated cylinder, NaCl, and H_2O. It can take the form of a series of laminated cards each with a single picture on a side, or a notebook with several pages. It is best that the pictures used to make the dictionary are taken in the lab environment so that they are direct representations of the materials, not stock pictures or drawings to ensure the most precise communication possible. If students have trouble writing out chemical reactions, a good alternative can be to provide element cards (laminated cards with different elemental symbols on them) and have the students line those up to show the

reaction. Students could be asked to either draw in bonds or use cards with Lewis dots or single, double, and triple bonds with and without polar charges.

Allowing students to type answers instead of writing by hand is another good accommodation for short answer and essay type questions. Students with communication impairments often benefit from a quiet space and extra time.

Be sure to provide whatever communication accommodations are used in class during testing to allow students to be able to seek assistance from the teacher. In all cases, be sure to work with the student to determine the most effective and appropriate ways to allow them to demonstrate knowledge as this is the end goal of testing.

Always allow extra time for communication to occur and a safe space for students to feel comfortable communicating. Students may prefer to communicate one-to-one with a teacher in a private environment instead of having to communicate in a whole class setting.[8-10]

9.5 Laboratory Considerations/Adaptations

The lab setting is inherently more fraught with communication issues than a classroom. The lab setting is much more dynamic — there are more things happening in the lab setting, and there are multiple people communicating different types of needs on different levels (within the lab group, with the lab instructor, with everyone in the lab). There is also a great deal of activity and sound interference from the environment.

It is very important to work out communication methods that will allow students with communication impairments to be successful in communicating needs for lab success and for safety. If possible, place the lab group in a corner or on an outside edge lab station with a buffer zone to minimize inter-group communication interference. Consider using acoustic sound boards on the walls to help with reverberation and allow for a cleaner sound environment. Allow the student with the communication impairment to select lab partners from students with whom they feel the most comfortable communicating, as this will minimize feelings of anxiety and maximize communication success.

It will be vital to take into consideration any additional disabilities or impairments and be sure that all needs are being met. This might involve the use of an assistant who could provide accommodation for multiple areas of impairment simultaneously. If an assistant is being utilized, it is important to be sure that the student is directing the assistant's activities, not that the assistant is taking over and doing the lab work for the student.

9.6 Assistive Technology

There are many different forms of assistive technology ranging from low to high tech options that can be utilized in the classroom and lab setting. The most common low tech options will be pencil and paper and personal white boards. Using visual aids with words and/or pictures can also be a good low-tech way to communicate, especially in a lab setting. Mid-tech options can be phones, tablets, and laptops equipped with text to speech apps/programs. Text-to-speech allows a person to type their message and have the computer voice it aloud. Phones, tablets, and computers can also be used to send print messages back and forth between

students. Phones and tablets can also have applications with word prediction, voice amplification, and other useful communication software. High tech options can be any form of assistive communication device. These are generally more specialized to the needs of the student and can be adapted more than simply using apps on a phone, tablet, or computer.[11]

It is important to remember that no matter what form of assistive technology is being used, students will require sufficient time to be able to receive, process and transmit communication messages. It is best if students can have prior knowledge of communication expectations for a specific activity so they can be prepared and able to communicate to the best of their ability.[8-10]

9.7 Considerations for Distance Learning

Distance learning can provide many benefits for students with communication disorders. Generally, materials have a print component or lectures are on video and can be watched multiple times as needed for clarity. Communication with classmates and instructors is generally via text methods, chat boards, email, etc. Students can demonstrate knowledge in different ways more easily due to not having to deal with in-class situations, which makes accommodations and modifications easier to provide.

9.8 Summary

Communication is how we impart information and assess learning in the classroom and is therefore one of the most important aspects of education. When students have communication impairments, they are at a significant disadvantage in the educational arena. It is vital that teachers and students work together to ensure that students are able to access the information expressed in class and are able to express their understanding of the material to ensure that learning has taken place. There are many different techniques given in this chapter that are a good starting point for ensuring accessible communication. This is not a complete and exhaustive list, but it is designed to be a good reference to provide ideas. The best way to ensure that communication is successful is to work as a team with all the individuals involved and find the exact mix of techniques that allows for maximal student success. Using multimodal communication options, verbal, haptic, written, pictures, communication devices, etc., can allow for full and complete communication to occur and can benefit not only the students with a communication impairment but also all students in the classroom.

9.9 References and Resources

1. American Speech-Language Hearing Association (ASHA). *Speech Sound Disorders - Articulation and Phonology*. https://www.asha.org/practice-portal/clinical-topics/articulation-and-phonology/ (accessed 2020-07-21)

2. ASHA. *Fluency Disorders*. https://www.asha.org/practice-portal/clinical-topics/fluency-disorders/ (accessed 2020-07-21)

3. National Stuttering Association. *Stuttering, What Employers Should Know*. https://westutter.org/wp-content/uploads/employers-2019-1.pdf (accessed 2020-07-21)

4. The Stuttering Foundation. *Straight Talk for Teachers Handbook.* https://www.stutteringhelp.org/stuttering-straight-talk-teachers-handbook (accessed 2020-07-21)

5. ASHA. *Spoken Language Disorders*. https://www.asha.org/practice-portal/clinical-topics/spoken-language-disorders/ (accessed 2020-07-21)

6. ASHA. *Written Language Disorders*. https://www.asha.org/practice-portal/clinical-topics/written-language-disorders/ (accessed 2020-07-21)

7. ASHA. *Social Communication Disorder*. https://www.asha.org/practice-portal/clinical-topics/social-communication-disorder/ (accessed 2020-07-21)

8. Rayburn, J. *Common Speech & Language Accommodations*, 2018. https://thespeechroomnews.com/wp-content/uploads/2018/04/IEP-Accomodations.pdf (accessed 2020-07-21)

9. Regents Center for Learning Disorders, Franklin College of Arts and Sciences, University of Georgia. *Accommodations and Instructional Strategies, Communications/Language Disabilities*. https://www.rcld.uga.edu/accommodations-and-instructional-strategies (accessed 2020-07-21)

10. *Language Disorders: Recommendations for Teachers*. https://www.education.udel.edu/wp-content/uploads/2013/01/LanguageDisorders.pdf (accessed 2020-07-21)

11. Northwest Augmentative Communication Society. *Learn about AAC*. https://nwacs.info/learn-about-aac (accessed 2020-07-21)

Chapter 10: Mobility and Fine Motor Skills Impairment

Patricia Ann Redden
Chemistry Department, Saint Peter's University,
2641 Kennedy Blvd., Jersey City, NJ 07306

Email: predden@saintpeters.edu

Chapter 10 Contents

10.1 Range of Needs
10.2 Accessibility Guidelines
10.3 Classroom Considerations and Adaptations
10.4 Testing

10.5 Laboratory Considerations and **Adaptations**
10.6 Assistive Technology
10.7 References

10.1 Range of Needs

Mobility impairments may affect a student's use of upper body, trunk or legs, while fine motor skills require the use of the muscles in the hands. In some cases, both may also affect other bodily functions that will have an impact on the student's daily activities. Mobility devices such as power or manual wheelchairs, scooters, leg or ankle braces, walkers, prostheses, crutches, or canes may be used; the student may also use a service dog or have a personal aide. It is necessary in the secondary school setting to consult the high school student's Individualized Education Program (IEP) and have a discussion with the student to identify needs and concerns on the part of the student. At the post-secondary level, discussion involving the college student, the institution's Disability Services for Students (DSS) personnel, and relevant departmental faculty to review the student's specific needs and to determine needed accommodations, particularly for the laboratory, should also be held prior to the beginning of each course. The student is obviously the best source of information and should participate fully in the discussion.

An important point here is the acknowledgement that having a motor impairment does not limit the student's ability to successfully complete a science program, as long as the necessary accommodations are made. Too often assumptions are made about the physical limitations of the individual using a wheelchair or with motor impairments, leading to such outdated and stigmatizing terms as "wheelchair bound." The reality is that the student may be an honor student, athlete, musician, artist, or writer, just as is the case with any other student.

It is impossible to review all the causes of and results of mobility and fine motor skills impairments, particularly since the same medical diagnosis may have widely divergent effects on individual students. In most cases, the instructor will not be told the cause of the disability because of medical privacy laws, only the accommodations to be made. It would be up to the

student to decide how much additional information to disclose, if any. However, to illustrate the complexity of the discussion that should be held with the student on accommodations, consider some causes of common permanent motor impairments and their associated effects.

- Cerebral palsy (CP) results from brain damage, usually occurring before or during birth, although in a few cases it may be within the first month after birth. The most common childhood motor disability, it primarily affects balance and mobility, and often speech. CP is not progressive, but as individuals age, different accommodations may be needed. A student with CP may walk independently, although there may be a visibly irregular gait. Alternatively, a mobility device up to and including a power wheelchair may be used. Spasticity may result in stiff muscles or jerky movements in the hands and arms, with resultant difficulty in handling laboratory equipment. In some cases, CP may be associated with limited or no ability to speak, epilepsy, or autism spectrum disorders.[1]

- Spina bifida is a neural tube defect, occurring when the spinal column and spinal cord don't develop properly *in utero*, leaving the spinal cord exposed along several vertebrae. Depending on where the spinal defect is, individuals with open spina bifida (myelomeningocele) may have mobility issues, walking with an irregular gait or using mobility devices, as well as a lack of sensation below the level of the spinal defect. Chiari malformation, a brain abnormality where the brainstem is elongated and lower than usual, may cause breathing problems. In the laboratory, latex allergy, often associated with spina bifida, must be considered when making a choice of laboratory gloves and tubing. Learning disabilities, particularly in math and reading, are often associated with spina bifida.[2]

- Paraplegia, quadriplegia, and hemiplegia, unlike spina bifida and cerebral palsy, may occur at any time during the individual's life. Paraplegia and quadriplegia are usually the result of an accident or injury to the spinal cord or brain, although they may be caused by a virus (polio or transverse myelitis,[3] for example). The result may be paraplegia (involving the legs and lower body) or quadriplegia (involving all four limbs), depending on the level of the spine where the injury occurred. To complicate the issue, paraplegia and quadriplegia may be complete or incomplete; if incomplete, some sensation or movement below the injury is possible, while complete quadriplegia or paraplegia results in a total loss of function and sensation below the injury.[4] Depending on the functional level, the student with paraplegia may use a manual or power wheelchair or may walk with mobility devices. Incomplete quadriplegia may limit the student's range of motion, hindering manipulation of laboratory equipment. A student with complete quadriplegia may require a head brace; since lung function may be affected, the student may require an oxygen tank or have a breathing (trach) tube as a result of a tracheostomy, creating additional safety considerations in the laboratory.[5] Hemiplegia or hemiparesis usually results from a stroke (including one in the womb), brain infection, or brain trauma. An individual with hemiplegia will have complete paralysis on one side of the body and may have trouble speaking or breathing, while hemiparesis is less severe and causes weakness or slight paralysis on one side of the body.[6]

- Muscular dystrophy results from a defective gene involved in making proteins to protect muscle fibers. It actually refers to a group of diseases that cause progressive weakness and loss of muscle mass, and it may begin at different ages and occur in different muscle groups. Complications can include difficulty walking, need for a wheelchair, contractures around joints, weakness in the arms or shoulders, and learning disabilities.[7]

- Partial limbs, missing limbs, or limb anomalies may involve legs, arms, feet, or hands. Limb anomalies are congenital and can be major or minor. Causes of amputations include trauma, cancer, some diseases (e.g., sickle cell anemia or diabetes), or treatment of phocomelia[8] (underdeveloped limbs). The amputation may have occurred at any age. A student with a leg amputation may use a wheelchair or a prosthesis, with or without crutches; a student with a missing arm or hand may have a functional or non-functional prosthesis. A student with a hand or arm prosthesis may or may not need help in carrying out laboratory operations.

- Balance problems can arise from a wide variety of causes and differ in severity, but most result from issues in the individual's inner ear (vestibular system). Other causes can include migraines, head injuries, cardiovascular disease, nerve damage to the legs, joint or muscle weakness, psychiatric disorders, paraplegia or other spinal injuries, or medications. The symptoms can include any of the following: sense of motion or spinning (vertigo), feeling of faintness or lightheadedness, loss of balance or unsteadiness, confusion, and dizziness. Some of the symptoms may be transitory, others will be more permanent. A cane might be used to reduce the possibility of a fall.[9]

- Fine motor function involves use of the hands. Hand tremors can result from an illness, disease, medication, or stress. Essential tremor is the most common cause, but a stroke, overactive thyroid, seizures, traumatic brain injury, and side effects of some medications can also lead to shaking hands.[10] Childhood arthritis, on the other hand, can cause stiffness in joints and lead to difficulty in daily activities; the symptoms may be intermittent.[11] Arthrogryposis involves contractures of multiple joints so they cannot fully extend or bend; most commonly the joints affected are in the upper extremities.[12]

There are many other sources and secondary consequences that have an effect on mobility and fine motor function, but these examples indicate that each situation must be evaluated individually. Discussion with all relevant parties about required accommodations is imperative.

It is also possible that a student may have a short-term need for accommodation because of mobility impairment resulting from an accident, sports injury, or surgery. Illness or pregnancy may also require a student to use a stool during the extended laboratory period. This may occur at any time before or during the semester and may last from a few weeks to several months. The needs of that student may require changes during an in-progress laboratory course.

10.2 Accessibility Guidelines

The institution, not the instructor, has the responsibility for ensuring that facilities are accessible.[13] However, the instructor should take a proactive role to ensure that the student's

needs are met in the individual classroom or laboratory, remembering that the mobility impairment may also be accompanied by other disabilities.

10.2.1 Evaluation of Needed Accommodations:

In evaluating the accommodations needed for an individual student, attention must be paid to both the mobility impairment and the related needs. As the examples above illustrate, this evaluation should place primary importance on the student's self-evaluation of abilities and needs, but it may also involve the student's aide (if any), occupational therapists, physical therapists, speech therapists, and/or learning specialists. The involvement of the laboratory instructor is also crucial in order to review the specific operations carried out in the laboratory as well as its physical layout.

10.2.2 Aides or Assistants

If the student has very limited upper body mobility, the student may already have a personal aide to help with carrying out functions of everyday life as well as classroom and laboratory tasks. An alternative would be for a laboratory partner or a more advanced chemistry student to assist in the laboratory rather than a generalist aide, although it is important that this be acceptable to the student and that the assistant only perform tasks prescribed by the student. Some students may prefer to work independently and should be allowed to do so, assuming it can be done safely. See the discussion on directed laboratory assistants in Chapter 3 (General Accommodations). More specific information on accessibility will be given in the classroom and laboratory sections below.

10.2.3 Service Dogs

Students with a mobility impairment will very often work with a service dog, who performs functions for its partner such as opening doors and drawers, picking up and carrying items, taking items from its partner to another individual, and even helping the partner to dress or undress. These tasks have parallels in the laboratory, but in that setting they would potentially result in serious harm to the service dog. Under the Americans with Disabilities Act (ADA), the student has the absolute right to bring the service dog into virtually any venue, and there is no problem with having the service dog in a classroom. The student also has the right to bring the dog into the laboratory, but accommodations may be necessary. Chapter 5 gives guidance on the questions that should be discussed with the student to determine the safest way to integrate the service dog into the laboratory or to care for it if the student decides not to bring it to the laboratory.[14-16]

10.2.4 Security Plan

It is very important that security personnel be aware of the schedule for both lecture and laboratory classes for students with mobility impairments, and there should be a plan available to security and department personnel for evacuation of the student in case of an emergency or accident. This information should include times that a student may be working on a research project outside of normal class periods. In an emergency, elevators may be unavailable, corridors and usual exit patterns may be blocked, and an alternative to the student's

wheelchair may be needed. If fire drills are held in a building, the drill should include the emergency evacuation plan for that student so everyone is familiar with the process.

10.3 Classroom Considerations and Adaptations

10.3.1 Location and Scheduling

Unless the building and the classroom are wheelchair-accessible, simply getting there may pose a problem for students with limited mobility, including those using crutches or walkers. If elevator access to upper-floor classrooms is unavailable, classes must be relocated to ground-level floors for students using mobility devices. Classrooms should have aisles that are wide enough for wheelchair users and other students with limited mobility. Doors should open without requiring students to grasp handles, and ideally the door should remain open until the student has passed through.

Students with limited mobility should have course schedules that provide adequate time to travel from one class to another. Students with mobility limitations may be unable to reach their next classroom in the standard time allotted between classes. Closely scheduled classes in distant buildings or areas of a large building should be avoided unless the student is confident about reaching the class in time. Faculty should be aware of the possibility that a student with mobility impairment may arrive late for class. Those who review material from the previous class may accommodate the student by presenting the review in the first few minutes and then giving the day's content, laboratory instructions, or other important information. However, it is the student's responsibility to catch up on material missed because of late arrival. At the high school level, the student may have an Individualized Education Plan (IEP) describing a formal arrangement that, for example, allows the student to leave class a given number of minutes early in order to make the following class on time.

10.3.2 Seating in the Classroom

Keep in mind that standard classroom seating and lecture hall desks were not designed for persons in wheelchairs, although some students may be able to transfer from the wheelchair to the seat. If the student remains in the wheelchair, and if seats cannot be moved or desk height cannot be easily adjusted to fit the wheelchair, simple adjustable tables can accommodate wheelchair users. In both standard classrooms and ramped lecture halls, the student should be able to choose between a seat in the front or in the back of the hall, to allow full participation in the class. If class work is done in small groups, consider how the student in the wheelchair can physically join and work with the group. The location of a lectern or laboratory table in the front of a classroom may limit visibility for a student in a wheelchair in the front of a lecture hall. Modification of other classroom areas may also be important to provide adequate accessibility.

10.3.3 Notetaking

A student may need help taking notes during class. That help should be coordinated with the disability services office at the institution. Possible accommodations would include providing a note-taker, recording the lecture, or receiving notes or slides in advance of the lecture.

10.4 Testing

Students whose fine motor function is impaired may require extra time on tests, scribes or an aide to record answers, or appropriate electronic devices to record their answers. For tests or assignments completed outside of the lab or classroom, students may choose to submit answers orally or in a digital format. Laboratory stations must, of course, be accessible when testing in the lab.

10.5 Laboratory Considerations and Adaptations

10.5.1 Laboratory Design

The student must be able to enter the laboratory door, navigate the aisles, and use lab benches, fume hoods, and other equipment. Emergency exits, showers, eyewashes, other emergency equipment, signage, and general facilities in the lab building such as restrooms and telephones must be accessible. This includes storage areas that are in the laboratory or otherwise open to students.

Figure 1: a student using a wheelchair accessible bench (photo by P. Redden)

Ultimately, students with limited mobility need adequate space to move freely. Wheelchair users need wide, clear aisles and adequate turning space to permit maneuverability and easy access to materials and equipment. Universal design guidelines in newly constructed or renovated facilities will have taken these needs into consideration, but many older laboratories may have narrower aisles and more constricted areas. Universal design includes providing tables and sinks with easily adjustable height and flexible placement of utilities and eyewash units. More information on laboratory design can be found in chapter 4 of this manual (Universal Design) and in *Accessibility in the Laboratory*,[13] a publication sponsored by the ACS Division of Chemical Health and Safety.

Ideally, every teaching laboratory should have at least one wheelchair-accessible workbench, out of the main travel paths in the laboratory. A wheelchair-accessible workbench (see Figure 1) should include a fume hood where appropriate and have a lower or adjustable work surface. An open area underneath allows a student using a wheelchair or stool to sit facing the bench and be closer to the work surface, and the student's lap is protected from spilled and dropped materials. This is particularly important if the student has a loss of sensation, since spills onto the student's lap or legs may not be noticed before skin damage occurs. This type of bench is also recommended for a student with a service dog, since the dog can be placed under the bench, where it will be fully protected and isolated from other students in the laboratory.

10.5.2 Wheelchair Design It is important to realize, however, that there is no "standard" wheelchair. Students use many different types of wheelchairs, including manually powered and electrically driven, and they have widely different dimensions, as shown in Figures 2–4. Some students may ride electric scooters or may use a wheelchair that converts to a standing frame, allowing them to work in a standing position. Power wheelchairs may be too large

Figure 2: a typical manual wheelchair

Figure 3: a power wheelchair

Figure 4: a standing wheelchair

for the recessed wheelchair location and may require a position parallel to the bench and hood, even though this is not ideal.

10.5.3 Working at the Laboratory Bench

The student's upper body mobility must be considered when identifying the best location for the student to work. To accommodate the variety of modern wheelchairs, work surfaces should be adjustable. ADA recommendations on depth and other dimensions of work surfaces are based on the most common wheelchair designs and do not apply to all models. Flexibility in the initial design of work areas will ensure that the laboratory will be usable by students with a variety of disabilities.

If a wheelchair-accessible workbench or table is not available, the student will have to work at a standard bench location, unless it is possible to set up a lower table for the student, out of the main traffic areas but near emergency equipment and exits. Positioning a wheelchair parallel to a laboratory bench or fume hood is a poor alternative to the recessed location. The parallel position is generally restrictive and makes it difficult and unsafe to perform many common laboratory tasks. The bench height will also be relatively high and awkward for a student in a manual wheelchair since it is designed for a standing person, not one sitting in a wheelchair. Utility controls and power outlets are usually placed toward the back of the bench to allow more usable space, so they may be out of reach. The student in this position will have to work with the upper body twisted at a right angle, a position that may be impossible for many; at best, it will leave the student's inner arm resting on the benchtop and vulnerable to spilled chemicals. Manipulating equipment and glassware will be difficult, and the potential for accidents is high. Setting up and using equipment for normal undergraduate experiments such as titrations and distillations will require assistance.

Instrument laboratories often are designed with lower bench heights to allow students to sit while using the instrument, and those benches will be more accessible for the student in a wheelchair. However, it may be necessary to put a sample in through the top of the instrument,

adjust gas flow on a standing gas cylinder, or perform other tasks that will be out of reach for the student. A laboratory partner may help carry out these tasks.

An ambulatory student with mobility impairment may be unable to stand for a full laboratory period, so a stool might be necessary even when stools are normally not allowed in the laboratory. If balance is impaired, that stool will need arms. Some students using walkers, crutches, or canes may be able to perform some laboratory tasks while leaning on the workbench or leaving one hand on the mobility device for support, while others will be able to stand without support for a period of time. In either case, consideration must be given to a safe location to keep the mobility device close at hand and in a location that will not impede other students in the laboratory.

10.5.4 Laboratory Operations

Just as there is no standard wheelchair, the accommodations needed by the individual using the chair cover a wide spectrum. A student with complete quadriplegia might only be physically able to use the joystick on the power wheelchair or point to objects with a head wand. A second student might have a fully functional trunk and arms, requiring a manual chair only for locomotion. A third student might have functional arms and hands but have balance issues. Each of these, and a myriad of other variations, will need different accommodations. For the most severely limiting conditions, it may be necessary to have an assistant (either a laboratory partner or another individual) to carry out the operations as directed by the student, effectively working as a directed pair of hands.

Laboratory operations must be evaluated for each individual student. Carrying chemicals from a central dispensing area is not possible for an ambulatory student using a mobility device and may also be a problem for a student with an irregular gait. The student in a wheelchair may be able to carry benign chemicals or equipment in a box or on a tray that is secured to the chair, but this would not be safe for more hazardous materials or for all students. A small cart may be a safer alternative for transportation in these cases, or a laboratory partner or assistant might be needed.

Appropriate laboratory glassware and equipment must be available, and each step of each laboratory procedure needs to be evaluated for the individual student. Using narrow-base glassware such as graduated cylinders, working with acids or bases, pouring solutions, and carrying out titrations will be difficult for a student with balance issues, spasticity, or limited use of their hands and arms. Adaptations might include providing non-breakable beakers and flasks, using beakers with handles, clamping graduated cylinders and Erlenmeyer flasks to avoid tipping, adapting the amounts of chemicals used to make measuring and handling easier, and having lever extensions on dials or valves. Mirrors tilted behind or above a stirring solution, distillation, or titration setup would help a student sitting in a wheelchair to monitor the procedure. Balances, pH meters, refractometers, microscopes, melting point apparatus, centrifuges, and other common laboratory apparatus should be set on a lower bench or table. Syringes and transfer pipets might be a problem for a student with minimal hand control or hand tremors. Dispensing and stock bottles for reagents should be evaluated for their ease of use. Adaptive equipment such as hand grips on forceps may help the student with limited hand mobility.[17,18]

10.5.5 Personal Protection

In terms of personal protective equipment, a student in a wheelchair should always use an impermeable apron, either plastic or rubberized, since laboratory coats and clothing will not adequately protect the lap and legs, and the student may have no sensation in the legs to provide warning of a spill. A student in a wheelchair who is working at a standard height bench would benefit from chemical resistant sleeves, in case of spills on the bench where the student's lower arm is placed. Placing the equipment and chemicals on a non-slip absorbent mat will also help to protect the student's arm. Glove material should be considered to prevent slipping as well as to provide chemical protection. Latex gloves must be replaced by nitrile gloves if a student has a latex allergy. A latex allergy would also mean that ordinary balloons and rubber tubing should not be used in the laboratory.

Proper hygiene in the laboratory includes never putting your hands to your face or mouth while working in the laboratory and washing your hands and arms with soap and water before leaving the laboratory.[19] For a student in a wheelchair or one using mobility aids such as crutches or a walker, any chemicals on their hands or gloves may have been transferred to the pushrims of the wheelchair or the hand pieces of the mobility device while working. To avoid contamination, they should first wash their hands and gloves thoroughly while still wearing the gloves, then wash and dry the pushrims of the wheelchair or hand pieces of the mobility device. The final steps would be to remove and properly dispose of the gloves, followed by washing their hands and arms with soap and water. If there is any possibility that the wheelchair may have gone through spilled liquid or solid chemicals on the floor, the tires themselves should be thoroughly cleaned before leaving the laboratory.

10.5.6 Showers and Eyewash Units

Particular attention should be given to showers and eyewash units. The handles on safety showers may be too high for a student in a wheelchair to reach without adding an extension, and the flood of water from the shower will present a major problem for an ambulatory student with or without mobility devices, even if there is a drain under the shower. Eye wash units are usually combined with a safety shower, wall mounted or on a laboratory bench. Combined or wall mounted units must have space for a wheelchair to approach and use the unit, and they must be at an appropriate height for that student. Again, consider the flooding that can result from the recommended time (15 minutes) the eye wash is in operation. A unit on a laboratory bench, particularly those that are mounted directly on a sink faucet, may be situated too far back for the seated student and it will almost always be too high. Some units are mounted on a hose, which may be able to reach beyond the table, but that may have to be hand-held during use and will also cause flooding. In case of an accident involving the eyes or face, eye wash units must be hands-free so the eyelids can be held open, so with these units the injured student would require an assistant to hold the eye wash or keep the eyelids open. Portable units are available, but they must be checked weekly for evaporation and bacterial growth, have an adequate reservoir for a 15-minute flush, be accessible and ready to use within 10 seconds, and meet ANSI standard Z358.1-2014.[20]

10.5.7 Virtual, Remote, and Home-Based Laboratory Instruction

An increasing number of K–12 students are being home-schooled rather than attending traditional classes, and their curriculum should include laboratory instruction. At the post-secondary level, students have the option of attending “brick and mortar” universities or enrolling in online courses and programs, which include laboratory sciences. During the spring 2020 semester, in the height of the COVID-19 pandemic, most academic institutions on all levels closed their campuses and moved to online instruction for both lecture and laboratory courses, a situation that lasted for up to 5 semesters. Chapter 4 provides a good review of the concerns and advantages of online lecture courses for students with disabilities, but the laboratory portion requires particular consideration for students with mobility impairments.

For the laboratory portions of these courses, many institutions use commercial laboratory simulation programs or videos developed by laboratory instructors to replace some or all of the hands-on laboratory work. These virtual options may require the use of assistive technology, as described in the following section, to perform laboratory options. Other institutions developed experiments using materials and chemicals easily available at home or from the supermarket, while others sent students kits containing the materials and chemicals needed.[21]

These options require physical manipulation of materials and should be closely evaluated to ensure that the student with a mobility impairment is able to carry out the operations. The remote laboratory sessions may be either synchronous (all students working simultaneously online) or asynchronous (students working individually at a time of their own choosing). Some basic questions to be asked include:

- Are chemicals (if supplied) in containers that can be opened by a student with limited use of hands or spasticity?
- Is equipment appropriate for the student?
- If the experiment requires making an instrument such as a spectrometer, conductivity device, or chromatography column, will the student need an assistant for the construction, or should the completed apparatus be part of the kit?
- Is the student able to manipulate the completed apparatus or will an assistant be available?
- Is the student able to safely carry out the experimental operations?
- If the laboratory is asynchronous, will the instructor be available while the student is working to respond to potential problems?

10.6 Assistive Technology

Figure 5: Keyboard for communication

Some students with limited mobility in their arms and hands can use a standard keyboard and mouse, touch screen, or touch pad to navigate a web page, use learning software, or control an instrument through a computer. Many others use a physical or virtual keyboard, with or without assistive devices such as a mouth-stick or head wand to access the keyboard, and they rarely if ever use a mouse or touchpad. Computer applications are available to take a voice command rather than tactile input. Students who are non-verbal may communicate with a partner or instructor with a speech-output device on a computer or by using a tablet containing letters, words, and/or symbols. Figure 5 shows such a tablet, which can be mounted on a wheelchair or bench. The display can be varied to suit the user's needs, and a laser pointer mounted on the student's head, controlled by head movements, would be used to select images, words, or letters.

Web page, learning software, and instrument software features that facilitate keyboard navigation are important for these individuals. When possible, software should avoid features that unnecessarily require multiple repetitive movements, which can cause fatigue in individuals using head wands and other assistive devices. Software that allows the user to navigate directly to a desired link, rather than proceeding through a lengthy list, is preferable.

10.7 References

1. 11 Things to Know about Cerebral Palsy. *Centers for Disease Control and Prevention*, USDHHS, 2022. https://www.cdc.gov/ncbddd/cp/ (accessed 2020-07-21)

2. Spina bifida. *Mayo Foundation for Medical Education and Research, Mayo Clinic*, 2022. https://www.mayoclinic.org/diseases-conditions/spina-bifida/symptoms-causes/syc-20377860 (accessed 2020-07-21)

3. Transverse Myelitis. *Mayo Foundation for Medical Education and Research, Mayo Clinic*, 2022. https://www.mayoclinic.org/diseases-conditions/transverse-myelitis/symptoms-causes/syc-20354726 (accessed 2020-07-21)

4. Kornick, J.; Spinalcord.com Team. Living with Paraplegia. *Spinalcord*, 2021. https://www.spinalcord.com/paraplegia (accessed 2020-07-21)

5. Denslow, E.; Flint Rehab. Incomplete Quadriplegia: Frequently Asked Questions. *Flint Rehab Neurological Recovery Blog*, 2021. https://www.flintrehab.com/incomplete-quadriplegia/ (accessed 2020-07-21)

6. Eyvazzadeh, A.; Han, S. Hemiplegia: Causes and Treatments for Partial Paralysis. *Healthline*, 2020. https://www.healthline.com/health/hemiplegia (accessed 2020-07-21)

7. Muscular Dystrophy. *Mayo Foundation for Medical Education and Research*, *Mayo Clinic*, 2022. https://www.mayoclinic.org/diseases-conditions/muscular-dystrophy/symptoms-causes/syc-20375388 (accessed 2020-07-21)

8. Grunebaum, A. Phocomelia - Shortened or absent arms or legs. *Baby Med*, 2019. https://www.babymed.com/thalidomide-phocomelia-shortened-or-absent-arms-or-legs (accessed 2020-07-21)

9. Balance Problems. *Mayo Foundation for Medical Education and Research, Mayo Clinic*, 2022. https://www.mayoclinic.org/diseases-conditions/balance-problems/symptoms-causes/syc-20350474 (accessed 2020-07-21)

10. Holland, K.; Martinez, K. Shaking Hands: What Are My Treatment Options? *Healthline*, 2021. https://www.healthline.com/health/treating-shaking-hands (accessed 2020-07-21)

11. Childhood Arthritis. *Centers for Disease Control and Prevention*, USDHHS, 2020. https://www.cdc.gov/arthritis/basics/childhood.htm (accessed 2020-07-21)

12. Arthrogryposis. *Johns Hopkins Medicine, The Johns Hopkins University*, 2022. https://www.hopkinsmedicine.org/health/conditions-and-diseases/arthrogryposis (accessed 2020-07-21)

13. Perry, J.; Baum, J., Assessing the Laboratory Environment. In *Accessibility in the Laboratory*; Sweet, E., Gower, W.S., Hetzel, C.E. Eds.; ACS Symposium Series; sponsored by the ACS Division of Chemical Health and Safety; Oxford University Press, 2018; Vol. 1272. DOI: 10.1021/bk-2018-1272 (accessed 2020-07-21)

14. Redden, P. Service Dogs in the Chemistry Laboratory, *J. Chem. Health Safety* **2016**, *23* (1), 32–34. DOI: 10.1016/j.jchas.2015.05.002 (accessed 2020-07-21)

15. Redden, P.; Sweet, C. Service Dogs in the Chemistry Laboratory. In *Accessibility in the Laboratory*; sponsored by the ACS Division of Chemical Health and Safety; Sweet, E., Gower, W.S., Hetzel, C.E. Eds.; ACS Symposium Series; sponsored by the ACS Division of Chemical Health and Safety; Oxford University Press, 2018; Vol. 1272. DOI: 10.1021/bk-2018-1272 (accessed 2020-07-21)

16. Redden, P. Service Dogs and Safety in Academic Laboratories, *J. Chem. Educ.* **2021**, ***98*** (1), 68–70. DOI: 10.1021/acs.jchemed.0c00073 (accessed 2020-07-21)

17. Boval, J.; Kennedy, S., Laboratory Safety for All: Accommodating Students with Disabilities in Chemistry Teaching Laboratories. In *Accessibility in the Laboratory*; Sweet, E., Gower, W. S., Hetzel, C. E. Eds.; ACS Symposium Series; sponsored by the ACS Division of Chemical Health and Safety; Oxford University Press, 2018; Vol. 1272. DOI: 10.1021/bk-2018-1272 (accessed 2020-07-21)

18. Burgstahler, S. Making Science Labs Accessible to Students with Disabilties. *DO-IT, The University of Washington*, 2012. https://www.washington.edu/doit/making-science-labs-accessible-students-disabilities (accessed 2020-07-21)

19. *Safety in Academic Chemistry Laboratories*, 8th ed.; American Chemical Society Committee on Chemical Safety, American Chemical Society: Washington, DC, 2017. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf (accessed 2020-07-21)

20. A Guide to the ANSI Z358.1-2014 Standard for Emergency Eyewashes and Shower Equipment. *Bradley Corporation*, February 16, 2016. https://www.bradleycorp.com/mediamanager/view/20293/Bradley_Safety_ANSIGuide.pdf (accessed 2020-07-21)

21. Salta, K.; Ntalakou, E.;Tsiortos, Z. Review of Hands-on Laboratory Experiments Employing Household Supplies. *J. Chem. Educ.* **2022**, *99* (7), 2563–2571. DOI: 10.1021/acs.jchemed.2c00037 (accessed 2020-07-21)

Chapter 11: Teaching Students with Learning Disabilities

Amie E. Norton
Department of Entomology, Kansas State University, Manhattan, KS 66506

Email: Amien@ksu.edu

11.1 Range of Needs
11.2 Classroom Considerations and Adaptations
11.3 Testing
11.4 Laboratory Considerations and Adaptations
11.5 Assistive Technology

11.1 Range of Needs

Learning Disabilities (LDs) describe a broad range of conditions that affect neurological processes used in reading, mathematics, and written expression.[1-3] Many LDs are invisible, so if a student doesn't disclose the disability, it is difficult to determine that one exists.[4,5] In general, students with LDs have average or above average IQs.[6] In the 1960s and 1970s, the term LD was used to fill an inconsistency in the educational system, since a number of students did not fit into the disability categories of the time and were disqualified from the special education system.[7,8] The term LD first appeared in the U.S. Department of Education's 1969 Learning Disability Act[9] and again in the 1975 Education for All Handicapped Children Act (EAHCA),[10] now known as the Individuals with Disabilities Education Act (IDEA).[11] The 1969 Learning Disability Act requires support services for students with LDs,[12] and the 1975 IDEA requires all public schools accepting federal funds to provide equal access to students with disabilities so that students of ages 3–21 have a right to free, appropriate special education and related services.[13] This law guarantees the right to timely evaluation, access to all meetings and paperwork, and transition planning for students and their guardians.[14] IDEA also provides federal funding for the additional cost of special education.[15] Another relevant piece of legislation is Section 504 of the Rehabilitation Act of 1973, which prohibits discrimination against people with disabilities by programs that are federally funded. Finally, the Americans with Disabilities Act of 1990 (ADA) protects people with disabilities in schools, the workplace, and other environments.[16]

Sixty-seven percent of students with a diagnosed LD enrolled in a college or community college within eight years of high school graduation.[17] Only 25% of students with a LD who received services in high school consider themselves as persons with a disability and request educational services in the post-secondary institution; only 17% of these students receive services.[18] In 2012, the National Center for Learning Disabilities (NCLD) surveyed 1,980 adults on their perspectives of the causes of LDs, with the results shown in Figure 1. Many respondents checked more than one cause, but the most common perceived causes were: IQ (43%), watching TV (22%), vaccinations (24%), poor diet (31%), environment (55%), laziness (51%), sensory impairment (40%), and intellectual disability (70%) (18).

Figure 1: 2012 Survey of Public Perceptions of LD, reprinted from reference (18) with permission.

In fact, LDs do not arise from environmental factors, poor parenting, psychological reasons, or an intellectual disorder.[19] The struggle in reading, writing, or mathematics occurs even though the student has normal or above normal intelligence, healthy emotional development, and plenty of learning opportunities.[20] Intellectual disabilities, not LDs, are linked to IQ.[21] Another common misconception is that laziness causes LDs; thus, the student just needs to work harder.[18] The best way to debunk these myths is by knowledge.

Learning disabilities are due to neurological variances in brain structure and function.[22] These changes affect the individual's capability to receive, store, process, retrieve, or communicate information.[23] Little is known or understood about the causes of LDs. However, there has been progress concerning which regions of the brain are affected by specific LDs.[24] Working with the understanding that LDs are caused by differences in brain structures, the need to develop different teaching strategies for different LDs can be rationalized.

There are seven types of LDs: dyslexia, dyscalculia, dysgraphia, auditory processing disorder (APD), visual processing disorder (VPD), nonverbal learning disability (NLD), and dyspraxia.

- Dyslexia is a language-based disorder that has a neurological basis.[25] This LD primarily affects adults and children who otherwise have normal or above average intelligence and makes up 80% of diagnosed LDs.[24] The disorder is characterized by difficulty in phonological processing, single word decoding, reading, spelling, and writing.[26] People with dyslexia show differences in the temporo-parieto-occipital brain regions compared to those without dyslexia.[27] Brain imaging indicated that, for those with dyslexia, the left posterior hemisphere functions differently when reading compared to the brain of someone who doesn't have dyslexia.[28] A diagnosis of dyslexia may come from a psychologist who examines the student's history, observes the student, and then makes a psychometric assessment.[29] The psychologist will determine if the reading difficulties are atypical for the student's age, intelligence level, and education level. The psychologist will then determine if the linguistic difficulties are due to phonological processing, or the ability to sound out words. Students with dyslexia tend to have a history of the following: delayed language development and difficulty in sounding out words, expressing themselves, reading and spelling, naming, and associating sounds with letters. They often have family members who have similar difficulties. The difficulty in reading is demonstrated by problems decoding words, slow and laborious reading, and inaccurately reading out loud. The student's comprehension may be better than single word decoding and poor spelling.

- Dyscalculia is an LD that is defined as an impairment in mathematics.[30] The signs of dyscalculia are difficulty with number sense, memorization of arithmetic facts, accurate calculation, and math reasoning.[31] Dyscalculia is described as a disparity between low arithmetic capacities and overall IQ along with age.[32] These arithmetic difficulties must occur over a long period of time. To diagnose dyscalculia, a test is administered with four components: computation skills, math fluency, mental computation, and quantitative reasoning.

- Auditory Processing Disorder (APD) is defined as an irregularity in the central auditory nervous system.[33] APD is an auditory deficit and not hearing loss or a higher-order cognitive, language, or related disorder. The main expression of APD is difficulty differentiating various sounds despite having normal peripheral hearing.[34] One symptom is the inability to understand speech among noise. There are three major components to the peripheral auditory system: the outer, middle, and inner ear.[35] However, central auditory processing is not well understood. The central auditory system has three parts: the brainstem, thalamus, and cortex.[36] Diagnosis requires different auditory tests performed by an audiologist:

    - Sound localization and lateralization
    - Auditory discrimination
    - Auditory pattern
    - Recognition of temporal aspects of audition, including temporal integration, temporal ordering, and temporal masking
    - Auditory performance in competing acoustic signals
    - Auditory performance with degraded acoustic signals

- Dysgraphia can be developmental or acquired.[37] Acquired dysgraphia occurs when there is a brain injury, disease, or a degenerative condition that results in the loss of previously acquired writing skills.[38] Developmental dysgraphia occurs in childhood for unknown reasons.[38] There are three different categories of dysgraphia: motor, spatial, and linguistic.[39] Motor dysgraphia is the lack of fine motor coordination and visual perception. Students with motor dysgraphia typically show the following symptoms: illegible and slow handwriting, poor drawing and tracing skills, and slow finger tapping.[37] Spatial dysgraphia is related to spatial perception, which affects writing and drawing ability. Students with spatial dysgraphia struggle with handwriting and drawing but their spelling and finger-tapping speed are normal.[37,39] Linguistic dysgraphia is related to the language processing skills required in the writing process. In linguistic dysgraphia, text that isn't traced or copied is illegible.[40] Drawing, copying, and oral spelling are not affected. To diagnose dysgraphia, a clinician will look at the following: written work, hand and body position, pencil grip, posture, and writing process.[40]

- Visual Processing Disorder (VPD) causes issues with how the brain processes visual information.[41] VPD can affect many different areas including difficulty in drawing or copying, inability to detect differences in shapes or letters, and letter reversal.[41] There are eight different types of VPD:

    - *Visual Discrimination Issues:* the student has difficulty seeing the deviation between comparable letters, shapes, or objects.

    - *Visual Figure Ground Discrimination:* the student cannot tell the difference between letters and the background.

    - *Visual Sequencing Issues:* the student doesn't see shapes, letters, or words in the accurate order, and may miss lines when reading or read the same line repeatedly.

    - *Visual-Motor Processing Issue:* the student has difficulty perceiving visual information, processing it, and moving their hands and body accordingly. This may be shown by a struggle to write within the lines or difficulty copying from the board.

    - *Long- or Short-Term Visual Memory Issues:* the student has a hard time remembering shapes and symbols that they have previously seen, causing difficulties with reading and spelling.

    - *Visual-Spatial Issues:* the student has problems understanding where objects are in space (i.e., how close two objects are to one another), which may result in difficulty taking in visual information in order to understand and create a meaningful pattern.

    - *Visual Closure Issues:* the student has problems identifying objects when only half of the object is revealed. This may be illustrated by a student having trouble finding an item when part of it is hidden or pulling the correct book out of a stack.

    - *Letter and Symbol Reversal Issues:* the student interchanges numbers and letters when writing.

    To diagnose VPD, the student will be given an eye examination to evaluate the visual system, examining eye focusing, teaming (how well the eyes work together), tracking, vision perception, and visual processing.

- Nonverbal Learning Disability (NLD) is defined as strength in verbal abilities combined with deficits in visual-spatial abilities.[42] A student with NLD struggles with fine and gross motor skills, spatial awareness, organization and planning, activities that require multitasking, staying focused, recalling visual information, peer relationships, reading social cues and interpreting social interactions, handling and understanding new situations, understanding

idioms, humor, and sarcasm, reading comprehension, essay writing, understanding charts and diagrams, and math skills.[43]

- Dyspraxia is a LD that affects motor skills (fine and gross), motor planning, and coordination.[44] Sometimes dyspraxia is called Developmental Coordination Disorder. The cause of dyspraxia is not known, but it occurs more often in males and is genetic.[45] It is not linked to intellectual ability. Currently there are no medical tests to diagnose dyspraxia. The diagnosis is made when motor skills are significantly below average for the student's age, which can have a persistent negative effect on day-to-day activities.

11.2 Classroom Considerations and Adaptations

Dyslexia: Students usually prefer PowerPoint handouts in advance to go over the material before lecture, and recorded lectures are helpful. Note-taking by someone else can also help some students with dyslexia. Methods for conveying information include using concept maps, demonstrating activities, as well as providing oral or written instructions, with text in Arial font and colored backgrounds instead of white, an inexpensive and easy way to do this is through the use of plastic color dividers.

Dyscalculia: Strategies that can help students with dyscalculia include reviewing concepts they already know before learning a new concept.[46] Talking through a problem can help a student retain information.[47] Writing out charts or drawing sketches will help problem solving. Highlight why certain math equations are important and connect math problems to real life to help with memorization. When reading a word problem, circle key words and break problems down into small steps.[48] Use visual aids when solving problems.

Auditory Processing Disorder (APD): When giving instructions, have the student restate the instructions.[49] When a key point is being made, highlight it in the lecture. Visual tools, images, and gestures can help student comprehension.[49] Test and classwork instruction can be broken down into short steps to help with understanding. When introducing new information, the following steps can help student comprehension: speaking clearly and slowly, giving preprinted material to the student before it is covered in class, and giving a list of key vocabulary terms for upcoming lessons. Having a short review and connecting the previous lessons to the new concept can be helpful. Students with APD need a quiet area for independent work where they can tune out audio distractions. They should sit closer to the instructor and away from doors, windows, and other distractions.

Dysgraphia: Accommodations for students with dysgraphia include providing a note-taker, providing lecture notes, or allowing the student to record the lecture.[50] Do not require students to copy problems from the board or book.

Visual Processing Disorder (VPD): Read aloud visual images on presentations.[51] Take time to summarize the key points of each lesson. When providing handouts, make sure there are no unnecessary images. Use a piece of paper to block out lines of text not being read. Highlight key information when reading. Graph paper can help with aligning the numbers in math problems. Having a note-taker or a preprinted copy of the notes can also help. The use of

simple diagrams or images can clarify written directions. Allow time for questions about the directions.

Nonverbal Learning Disability (NLD): Create a classroom routine. Ensure that the class rules and schedule are clearly stated and posted.[52] Provide verbal cues before a transition. Give the student time to preview and prepare for new activities such as group projects and events that change routine. When giving a short review, make a connection to the previous lesson's important concepts before presenting new ideas. Clearly state objectives using simple and clear language. If jokes or figures of speech are used, explain them. When giving directions, speak slowly and provide them in writing where possible. Provide guided notes that focus on key points when practical. Present large assignments or projects in a series of small steps.

Dyspraxia: Provide the student with pencil grips; the use of graph paper and raised line paper can help with writing.[53] Students may require the use of different writing tools such as thin markers or gel pens that reduce pencil pressure. When giving instructions, furnish them in writing ahead of time or provide a note-taker. The use of large print for worksheets, notes, and textbooks can be helpful. Students should have chairs and desks adjusted to the right height to help with better posture. Students should be allowed to work in different positions, including standing. A slanted board can help as a writing surface.

11.3 Testing

Dyscalculia: Allow the student to have a list of math formulas that are taught in class and allow the use of a calculator when computation isn't being assessed.[54]

Dysgraphia: Have the student use a letter strip when they forget how letters are formed.

Visual Processing Disorder (VPD): When giving oral directions, leave time for clarifying questions. Make sure words and problems are spaced well and the spacing is consistent on a page or the board. Use a different color for the directions than for the rest of the assignment or examination. When completing tests and assignments, allow the students to have additional paper to fit the answers.[55]

11.4 Laboratory Considerations and Adaptations

Many of the considerations used in the classroom can also be used in the laboratory. Many of these suggestions help not only students with disabilities but also all students and are easy to implement.

Dyslexia: Students can use reader pens to read laboratory handbooks. They may also use pre-recorded audio laboratory books if they are available. Students may take laboratory notes electronically or use a recorder and later transcribe into the laboratory books. An online laboratory notebook can be a good tool, and YouTube videos that demonstrate important skills can also be helpful (such as a video on how to set up a distillation apparatus). Labels on reagent bottles should have chemical formulas, names, and picture graphs for hazards.

Dyscalculia: When presenting equations, explaining how they were derived can help a student with Dyscalculia. Relating equations used in the laboratory to corresponding concepts from the lecture may be helpful.

Auditory Processing Disorder (APD): YouTube videos focused on laboratory techniques can be very helpful to a student with APD.

Dysgraphia: Voice recorders can be used to record observations in the laboratory; the student can listen to the recording and write the notes into a notebook at a later time. Online laboratory notebooks can also be useful, but if they are not available, typing the information and taping or pasting it into an official notebook may work well.

Visual Processing Disorder (VPD): When providing handouts make sure there are no unnecessary images. Give the laboratory instructions one step at a time, and have the student block out the other steps with a piece of paper. Leave time for questions after going over instructions. It is useful to have different handouts that show the information in different ways for different students, or have a file were students can write or edit the handouts to make the notes in the best way that works for them.

Nonverbal Learning Disability (NLD): Create a routine in the laboratory (for example, begin with a pre-lab discussion before starting the lab). Make sure the student is aware of the safety considerations for each laboratory procedure and knows the rules of the laboratory. Help students make connections between the laboratory and lecture. Give both written and verbal instructions. Similar to the suggestion for VPD, use a piece of paper to block out multiple steps and show the student only one or two steps at a time.

Dyspraxia: Allow the student to use online laboratory books. Allow the student to type reports and then tape or paste the content into the laboratory book. Allow the student to tape-record observations then write them in the lab book at a later time.

11.5 Assistive Technology

Dyslexia: Students with dyslexia may use word processing software (such as Microsoft Word) to write, and they often use Google or use Wikipedia to look up the definitions of words they don't know. Most students with dyslexia use spell check, but they frequently will not use the syntax check program on their computer. Many students with dyslexia summarize the books they are reading on their computers. A free program that can be useful is Natural Voices, where the reading is not in synthetic style. Some students use daisy-books (Digital Accessible Information System), where the reading is recorded by a person. The use of reader pens (such as a C-reader pen) is helpful. An OrCam (a smart device that reads text, recognizes faces, and more) can be used. Commercially available Reading Focus Cards isolate one or two lines of text and block out surrounding text. Sometimes a different contrast will help a dyslexic student read, so a color strip will help improve their reading. Voice recorders can help students with dyslexia record their thoughts in the moment to later be transcribed on a computer.

Dyscalculia: Graphing paper helps students as they line up numbers. A calculator can be helpful, particularly a talking calculator. Apps that show a large calculator can also be helpful, such as the Big Calculator App used on a smartphone or iPad.

Auditory Processing Disorder (APD): Assistive listening devices can be used to distinguish the voices students want to hear. Earbuds can be used to reduce the background noise. A remote microphone, worn by the instructor, while the student wears an earpiece, amplifies the teacher's voice.

Dysgraphia: Have the student use voice-recognition software such as Dragon. Allow the student to type reports. There are apps such as PaperPort that allow students to do a worksheet on an iPad. Notetaking technologies such as AlphaSmart and Livescribe can also be helpful.

Visual Processing Disorder: The use of text-to-speech software or audiobooks can be helpful. Talking or large print calculators can also be very helpful. Screen reading software products such as JAWS (for Microsoft) are useful.

Dyspraxia: Talk-to-text technology is helpful. Using a computer for all written assignments is also beneficial. An oversized trackball mouse can be useful as well as a robotic arm that holds a pen. The robotic arm helps with handwriting and connects to a computer. An iPad will read 36 languages as a built-in accessibility feature. NaturalReader is a free text to speech online app that can be downloaded to read online text to the student. Mind-mapping apps can be used to organize thoughts.

11.6 References

1. Harris, A.M.; Cancelli, A. A. Academic engagement of students with learning disabilities in mainstream classrooms: Challenging conventional wisdom. *J. Educ. Psychol. Consult.* **1993**, 4 (4), 385–389.

2. Kavale, K.A.; Forness, S.R. What definitions of learning disability say and don't say: A critical analysis. J. Learn. Disabil. **2000**, *33* (3), 239–256.

3. Wasserman, D.; et al. *Disability: Definitions, models, experience.* 2011.

4. Dreyer, L.; Mostert, Y.; Gow, M.A. The promise of equal education not kept: Specific learning disabilities–The invisible disability. *Afr. J. Disabil*. **2020**, *9* (1), 1–10.

5. Yadav, A., The invisible disabilities. *Learning Curve*, **2019** (5), 24–28.

6. Assouline, S.G.; Foley Nicpon, M.; Whiteman, C. Cognitive and psychosocial characteristics of gifted students with written language disability. *Gifted Child Q.* **2010**, *54* (2), 102–115 Reschly, D.J.; Hosp, J.L. State SLD identification policies and practices. *Learn. Disabil. Q.* **2004**, *27* (4); 197–213.

7. Reschly, D.J.; Hosp, J.L. State SLD identification policies and practices. *Learn. Disabil. Q.* **2004**, *27* (4); 197–213.

8. Mercer, C.; Hallahan, D. Learning disabilities: Historical perspectives. In *Identification of learning disabilities: Research to practice*; Lawrence Erbaum Associates, 2002; pp 1–65.

9. Paul, C.A. *Elementary and secondary education act of 1965.* Social welfare history project, 2016.

10. Zettel, J.J.; Ballard, J. The education for all handicapped children act of 1975 PL 94-142: Its history, origins, and concepts*. J. Educ.* **1979**, *161* (3), 5–22.

11. Lipkin, P.H.; Okamoto, J. The Individuals with Disabilities Education Act (IDEA) for children with special educational needs*. Pediatrics* **2015**, *136* (6), e1650–e1662.

12. Kavale, K.A.; Spaulding, L.S.; Beam, A.P. A time to define: Making the specific learning disability definition prescribe specific learning disability*. Learn. Disabil. Q.* **2009**, *32* (1), 39–48.

13. Katsiyannis, A.; Yell, M.L.; Bradley, R. Reflections on the 25th anniversary of the Individuals with Disabilities Education Act*. Remedial Spec. Educ.* **2001**, *22* (6), 324–334.

14. Yell, M.L.; Shriner, J.G. The IDEA amendments of 1997: Implications for special and general education teachers, administrators, and teacher trainers*. Focus Exceptional Child.* **1997**, *30* (1).

15. Hermann, A.M.C. Sports and the Handicapped: Section 504 of the Rehabilitation Act of 1973 and Curricular, Intramural, Club and Intercollegiate Athletic Programs in Postsecondary Educational Institutions*. J. Coll. Univ. Law* **1977**, *5* (2), 143.

16. Bishop, P.C.; Jones, A.J., Jr. Implementing the Americans with Disabilities Act of 1990: Assessing the variables of success*. Public Adm. Rev.* **1993**, *53* (2), 121–128.

17. Schlagel, C.A. The importance of transition planning for high school: School students with learning disabilities*.* Southwest State University, 2001.

18. Cortiella, C.; Horowitz, S.J. *The State of Learning Disabilities*, 3rd ed.*;* National Center for Learning Disabilities, 2014. https://www.ncld.org/wp-content/uploads/2014/11/2014-State-of-LD.pdf

19. Fletcher, J.M.; Grigorenko, E.L. Neuropsychology of learning disabilities: The past and the future*. JINS, J. Int. Neuropsychol. Soc.* **2017**, *23* (9–10), 930.

20. Jensen, E. *Teaching with the brain in mind*, 2nd ed.; ASCD, 2005.

21. Ruban, L.M. Identification and assessment of gifted students with learning disabilities*. Theory Pract.* **2005** *44* (2), 115–124.

22. Gilger, J.W.; Kaplan, B.J. Atypical brain development: a conceptual framework for understanding developmental learning disabilities*. Dev. Neuropsychol.* **2001**, *20* (2), 465–481.

23. Berninger, V.W. Defining and differentiating dysgraphia, dyslexia, and language learning disability within a working memory model*.* In *Brain, behavior, and learning in language*

and reading disorders; Mody, M., Sillman, E.R., Eds.; The Guilford Press, 2008; pp 103–134.

24. Berninger, V.W.; Richards, T.L.; Abbott, R.D. Differential diagnosis of dysgraphia, dyslexia, and OWL LD: Behavioral and neuroimaging evidence*. Reading Writing* **2015**, *28* (8), 1119–1153.

25. Peterson, R.L.; Pennington, B.F. Developmental dyslexia*. Lancet* **2012**, *379* (9830), 1997–2007.

26. Snowling, M., Dyslexia as a phonological deficit: Evidence and implications*. Child Psychol. Psychiatry Rev.* **1998**, *3* (1), 4–11.

27. Shaywitz, B. A.; et al. Disruption of posterior brain systems for reading in children with developmental dyslexia*. Biol. Psychiatry* **2002**, *52* (2), 101–110.

28. Pugh, K.R.; et al. The angular gyrus in developmental dyslexia: task-specific differences in functional connectivity within posterior cortex*. Psychol. Sci.* **2000**, *11* (1), 51–56.

29. Callens, M.; Tops, W.; Brysbaert, M. Cognitive profile of students who enter higher education with an indication of dyslexia*. PloS One* **2012**, *7* (6), e38081.

30. Williams, A. A teacher's perspective of dyscalculia: Who counts? An interdisciplinary overview*. Aust. J. Learn. Difficulties* **2013**, *18* (1), 1–16.

31. Von Aster, M.G.; Shalev, R.S. Number development and developmental dyscalculia*. Dev. Med. Child Neurol.* **2007**, *49* (11), 868-873.

32. Butterworth, B. Foundational numerical capacities and the origins of dyscalculia*. Space, time and number in the brain*; Academic Press, 2011; pp 249–265.

33. Moore, D.R. Auditory processing disorder (APD): Definition, diagnosis, neural basis, and intervention*. Audiol. Med.* **2006**, *4* (1), 4–11.

34. Beck, D.L.; Danhauer, J.L.; Abrams, H.B.; et al. *Audiologic considerations for people with normal hearing sensitivity yet hearing difficulty and/or speech-in-noise problems.* 2018.

35. Weiss, T.F. A model of the peripheral auditory system*. Kybernetik* **1966**, *3* (4), 153–175.

36. Langers, D.R.; van Dijk, P.; Backes, W.H. Lateralization, connectivity and plasticity in the human central auditory system*. Neuroimage* **2005**, *28* (2), 490–499.

37. Gubbay, S.S.; de Klerk, N.H. A study and review of developmental dysgraphia in relation to acquired dysgraphia*. Brain Dev.* **1995**, *17* (1), 1–8.

38. Deuel, R.K. Developmental dysgraphia and motor skills disorders*. J. Child Neurol*. **1995**, *10* (1_suppl), S6–S8.

39. McCloskey, M.; Rapp, B. Developmental dysgraphia: An overview and framework for research. *Cognit. Neuropsychol.* **2017**, *34* (3–4), 65–82.

40. Chung, P.; Patel, D.R. Dysgraphia. *Int. J. Child Adolesc. Health* **2015**, *8* (1), 27.

41. Janarthanan, S. Visual processing disorder in children. *Ophthalmol. Open J.* **2017**, *2* (2), 45–47.

42. Mammarella, I.C.; Cornoldi, C. An analysis of the criteria used to diagnose children with Nonverbal Learning Disability (NLD). *Child Neuropsychol.* **2014**, *20* (3), 255–280.

43. Banker, S.M.; et al. Spatial network connectivity and spatial reasoning ability in children with nonverbal learning disability. *Sci. Rep.* **2020**, *10* (1), 1–10.

44. Hurst, C.M.; et al. Improvements in performance following optometric vision therapy in a child with dyspraxia. *Ophthalmic Physiol. Opt.* 2006, *26* (2), 199–210.

45. Richardson, A.J.; Ross, M. Fatty acid metabolism in neurodevelopmental disorder: a new perspective on associations between attention-deficit/hyperactivity disorder, dyslexia, dyspraxia and the autistic spectrum. *Prostaglandins, Leukotrienes Essent. Fatty Acids* **2000**, *63* (1–2), 1–9.

46. Butterworth, B.; Varma, S.; Laurillard, D. Dyscalculia: from brain to education. *Science* **2011**, *332* (6033), 1049–1053.

47. Wadlington, E.; Wadlington, P.L. Helping students with mathematical disabilities to succeed. *Prevent. School Failure: Altern. Educ. Child. Youth*, **2008**, *53* (1), 2–7.

48. Butterworth, B. Developmental dyscalculia. In *Handbook of mathematical cognition*; Campbell, J. I. D., Ed.; Psychology Press, 2005; pp 455–467.

49. Johnson, C.D. Individual Educational Planning and Resources for APD. In *An Introduction to Auditory Processing Disorders in Children*; Psychology Press, 2014; pp 217–242.

50. Chang, M.K. *Accommodating Students with Disabilities: A Guide for School Teachers*; Alabama State University, 1996.

51. Tufte, E.R.; et al. *Visual explanations: Images and quantities, evidence and narrative*; American Institute of Physics, 1998.

52. Murphy, M.B. *NLD from the inside out: Talking to parents, teachers, and teens about growing up with nonverbal learning disabilities*; Jessica Kingsley Publishers,2016.

53. Portwood, M. *Understanding developmental dyspraxia: A textbook for students and professionals*; Routledge, 2013.

54. Cornue, J.W. Exploring Dyscalculia and Its Effects on Mathematics Students. Master's Thesis, Harvard University, 2018.

55. Hodge, B.M.; Preston-Sabin, J. *Accommodations—or Just Good Teaching? Strategies for Teaching College Students with Disabilities;* Greenwood Publishing Group, 1997.

Chapter 12: Invisible Disabilities and Chronic Illness

Sarah R. Zinn

Department of Chemistry and Center for Laboratory Safety, University of California Los Angeles, 607 Charles E. Young Dr. East, Los Angeles, CA 90024

Email: szinn@ucla.edu

Chapter 12 Contents

12.1 Introduction

12.2 Range of Needs

12.1 Introduction

Every year, more and more young adults experience disability and chronic illness—and this trend is increasing dramatically.[1,2] In the United States, more than a quarter of adults are living with a disability of some kind and almost half are chronically ill.[3,4] But while these numbers are shockingly high, they are almost certainly an underrepresentation of reality.[5] Many people face barriers to obtaining official certification of their disability or illness, including limited financial resources,[6-8] administrative and insurance barriers,[9-11] social stigma,[12-17] biased diagnostic criteria,[18-20] and poorly knowledgeable medical practitioners.[21-24] Indeed, undiagnosed diseases are common and, though difficult to count, are estimated to affect nearly 10% of Americans,[25] a number which is likely an underestimation and may also be expected to rise dramatically in the wake of COVID-19 and its post-viral impacts.[26-27]

Many of these disabilities and chronic illnesses, however, are not readily visible to others. Even though these obscured conditions—called invisible disabilities—may substantially impact the way that students experience your course, many people with invisible disabilities choose not to—or are unable to—report their condition to their educators or their institutions. In a survey of over a thousand respondents, Coqual—formerly known as the Center for Talent Innovations—found that 62% of disabilities were invisible, with respondents disclosing their condition to their employers, team leaders, or HR representatives only on a “need to know” basis.[28] Further, some conditions which impact students’ experience of your course *are* visible but are often not considered in classroom development or structure. Therefore, this chapter will be dedicated to both invisible and under-recognized visible conditions that many of your students may be experiencing.

After providing an overview of various ways in which students may be impacted, this chapter will present a broad perspective on how educators can adjust their teaching practices to meet the needs of all of their disabled or ill students without requiring them to self-report. The goal of this chapter is not to suggest that educators should know every possible need their students

may have or accommodate them on an individual basis. Instead, the goal here is to help educators start to think differently about how they design their classes and assessments as a whole. The *Range of Needs* section that follows may feel overwhelming to some, but it is important to keep in mind that this section is simply to help educators achieve perspective on

The Stigma and Misconceptions of Invisible Disabilities

Invisible illnesses and disabilities can have major impacts on an individual's daily life. Yet, these individuals constantly experience stigmatization or disbelief from others, who often call into question everything from their motivation to their honesty. As Lydia Aimone, a chronically ill member of the Anti-Stigma Project puts it:[29]

> People tend to doubt the reality of things that they cannot see, so these symptoms or their severity are often called into question. If you look fine, you are fine. This assumption leads to erroneous conclusions that 1) you are not working "hard enough" to push through symptoms, 2) you are making up symptoms as excuses to avoid responsibilities, or 3) your symptoms are your fault, either because of bad choices or because there is something inherently wrong with you. The result of that stigma is harmful on many levels, including exacerbating symptoms, creating barriers to success in relationships and vocation, and even impacting one's identity and self-worth.

Young people with invisible disabilities and illnesses especially are often accused of "making excuses," being "lazy," "taking advantage of the system," and more. Reading this, we may all think—and maybe hope—that we are above this type of stigmatization, but ask yourself: if a young student—who has always looked perfectly well to you—frequently missed class and then asked for an extension on a large project, how would you feel? Would you question their motives? Would you assume they didn't manage their time well? Would you be afraid that you or your class were being taken advantage of? Or maybe, you would be concerned that they would use your generosity to cheat. In the end, would you give them the extension they needed to succeed? Even I—a chronically ill student and educator—have hosted these stigmatizing and faulty assumptions.

In the end, what's more important—providing educational accessibility to students who need it in order to succeed and to thrive, or restricting resources from the few individuals keen on taking advantage? And how do you tell the difference between these students?

the extraordinary diversity of students' physical and mental realities—many of the most effective accommodations are simple, broad, class-wide policies.

12.2 Range of Needs

There are a great many conditions that could be discussed here. Indeed, this topic could warrant an entire book series all on its own. Given the extraordinary diversity of conditions and the limited space, we will not attempt to describe every possible condition that your students may be experiencing. Instead, here we have provided an overview of eight major categories of function that are commonly impacted by invisible disabilities and chronic illness (Figure 1).

Within each category, we will discuss possible ways in which these impacts may affect students' experience and participation in the classroom, including specific examples of conditions. The needs presented in this chapter are to orient educators to the possible ways that students may be interacting with their courses, and to help educators understand the reasoning behind the broad, class-wide policy recommendations presented in Sections 12.3–12.6.

Additionally, it is important to note that students with disabilities or chronic illnesses are often highly practiced problem solvers who are experts in their own needs and in effective strategies for moving through a world not built for them. It may be more realistic to think of your disabled or ill students not as individuals needing special treatment, but instead as students with unique ways of thinking and valuable perspectives that help them see the world — and chemistry — differently, and therefore interact with your course differently. However, it is also important to remember that many illnesses and disabilities first begin presenting at puberty and in early adulthood. As such, it is reasonable to expect that some of your students will just be starting their ill and disabled journeys while in your class. Though some of your students will already be experts in navigating through the world and through academia ill or disabled, some will be in the midst of learning how to readjust to meet their new needs—and many will not even yet realize that they are ill or disabled (this does *not* imply that their conditions are not serious enough to interfere substantially with their daily lives; it simply means that they have not yet been able to connect the dots).

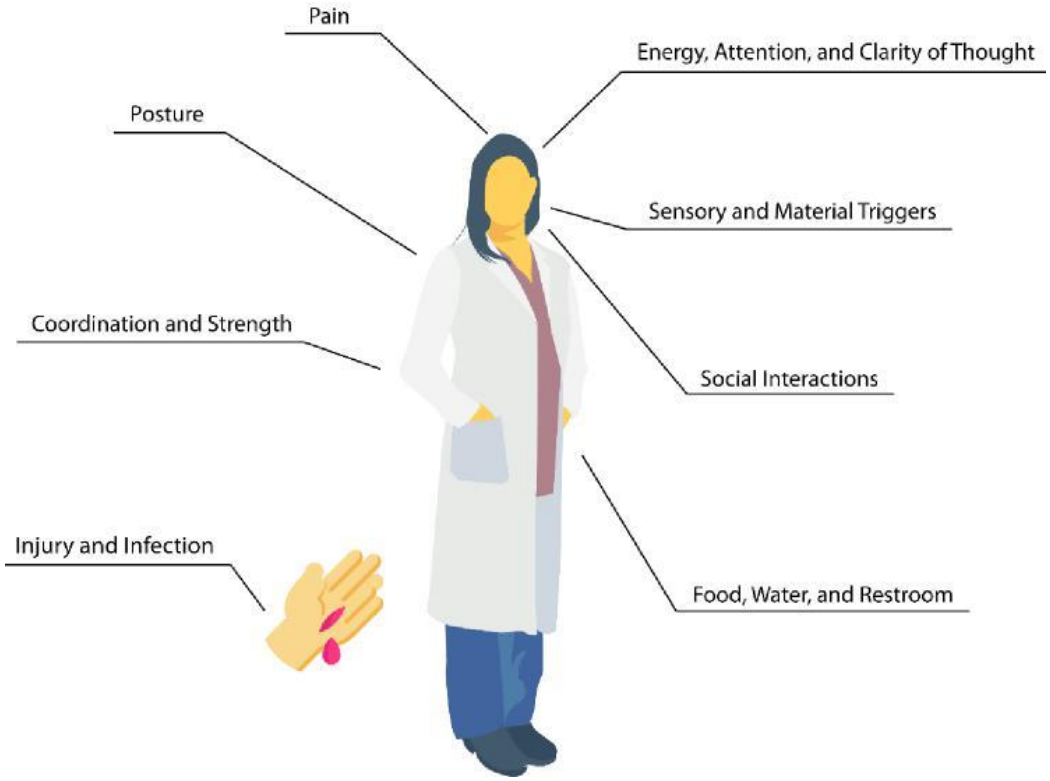

Figure 1: **An overview of the categories of function most commonly impacted by invisible disabilities and chronic illnesses. The categories are pain; posture; coordination and strength; injury and infection; energy, attention, and clarity of thought; sensory and material triggers; social interactions; and food, water, and restroom.**

12.2.1 Altered Energy, Attention, and Clarity of Thought

12.2.1a Reduced Energy: Sitting in a diner with her roommate who asked her to explain what it was like to be chronically ill, college student Christina Miserandino handed her friend a handful of spoons, taken from the tables around them. She explained that "most people start the day with unlimited possibilities, and energy to do whatever they desire," but that being chronically ill means "having to make choices or to consciously think about things when the rest of the world doesn't have to." She asked her friend to count her spoons, and then to go through her day, discarding a spoon for every task. Before her friend got to work, half of her spoons were already gone, and getting to work would take even more.[30] This personal story by Christina Miserandino is the origin of Spoon Theory and is a major basis by which disabled and chronically ill communities—who sometimes refer to themselves as "spoonies"—discuss the energetic demands and limitations of their conditions. Reduced energy is a very commonly shared symptom of many disabilities and illnesses, not only because it is a common physiological symptom of many conditions,[31-34] but also because of the sheer amount of physical and mental

resources that are required to manage illness and disability—along with the impact that it can have on sleep, often referred to as “painsomnia” in the community.[30]

In the classroom, spoon management can mean that students with disabilities or chronic illnesses have to make prioritization requirements that you may not anticipate when designing your course. When taking multiple classes, students may have overlapping exams and projects, or daily personal tasks may sometimes take priority over homework. Early-morning classes may be more difficult to attend than afternoon classes, and in-person classes even more so than remote classes. Additionally, many conditions go through cycles of waxing and waning, with periods anywhere from days to decades. Some students may experience periods of low symptom intensity for most of the quarter or semester, and then suddenly start experiencing more intense symptom presentation later in your course and require more accommodations than they did before. These periods of higher intensity symptom presentations are known as “flares,” and if a student is unable to spend the spoons needed to recover after a flare, the flare can worsen dramatically or continue for a more extended period of time.

Examples: Myalgia Encephalomyelitis or Chronic Fatigue Syndrome (ME/CFS), Anemia, Dysautonomia, Depression, Sleep Disorders, Hashimoto’s, Eating Disorders

12.2.1b <u>Atypical Attention</u>: Similarly, to the effects of chronic illness and disability on energy reserves, attentional resources can also be affected broadly by many different conditions, both as a primary physiological symptom and as a secondary response to other condition-related factors. Some students may experience very scattered attention, with highly fluctuating but acutely clear attention, while others may experience fuzzy and non-directional attention. Others, however, may experience hyper-focused attention or intense interest in a particular topic, and have difficulty moving on to different tasks or concepts. As with energy, attentional resources can fluctuate with time and external circumstances, and some students may even experience multiple phenotypes of attentional control at different periods in their illness or disability, sometimes experiencing hyper-focused attention and special interest, while other times experiencing jumping attention.

Attention plays an important role in the classroom and understanding different ways in which your students may be leveraging their attentional resources can help you more effectively teach individuals with different neurotypes and physical realities. For students

Did You Know?

Autism is a broad and very diverse spectrum. In many cases, it is not possible to tell that a person has autism by looking at them or even by interacting with them. 1 in 44 children are diagnosed with autism, and this figure increases every year.[35] Despite growing numbers of diagnoses, many people still remain undiagnosed with autism as adults, especially people assigned female at birth. These individuals may be better at masking their autism as a learned survival trait.[36-37]

with more scattered attention, it may be more difficult to stay working on one task for an extended period of time or to stay physically still or seated. Additionally, these students may rely on attentional momentum to complete tasks, such that once their momentum is broken, it becomes very difficult for them to return to the original task, sometimes requiring them to start the task over from the beginning. On the other hand, students with hyper-focused attention may have a lot of questions about a single topic or may find it difficult to move on from a topic until they have explored it in depth. In some cases, their focus might be pointed toward a task that is not related to your course and may have a difficult time paying attention in class, and in other cases their focus might be pointed toward material presented in class and may ask many questions that may seem disruptive. Some students may use stimulation toys during class to provide self-stimulation, which is a common strategy used by some to aid them in managing their attention (see *Assistive Technology*).

Examples: Attention Deficit Hyperactive Disorder (ADHD), Autism Spectrum Disorder (ASD), Anxiety, ME/CFS, Acquired or Traumatic Brain Injury (ABI or TBI)

12.2.1c <u>Reduced Clarity of Thought</u>: Related but distinct to the energy and attention topics discussed above, clarity of thought describes the degree to which your students can form clear mental articulations of concepts, thoughts, and ideas. Often, individuals with disabilities or chronic illnesses experience “brain fog,” which is a description used to explain difficulty thinking quickly, clearly, and precisely. When experiencing brain fog, it can be difficult to recall information, to convey information, or to process information — especially under pressure. In an attempt to describe it, chronically ill blogger Ashley Seymour wrote that it's like “trying to think through mud. It’s as if I have to concentrate on every word to be able to get it from my memory to mouth without disruption. Facts and numbers I may have known for years become blurry and I question everything before I say it.”[38] Just as reduced energy and atypical attentional profiles are common in individuals with highly diverse chronic illnesses or disabilities, brain fog is also a very common experience and is expected to become more common as a result of the COVID-19 pandemic.

In the classroom, students experiencing brain fog may need additional time to prepare responses to questions, or they may need to free up cognitive resources by offloading mental tasks onto the environment. Students may write things down, draw pictures, count on their fingers, use a calculator, or otherwise use their physical environment to keep track of and process information to better leverage their available mental resources. Students who have only recently started experiencing brain fog may not have yet adjusted their studying habits and strategies to fit their new needs and may have an extremely difficult time studying or doing homework.

Examples: ME/CFS, Depression, Chronic Pain, Sleep Disorders, Postural Orthostatic Tachycardia Syndrome (POTS), Polycystic Ovarian Syndrome (PCOS)

12.2.2 Trigger Sensitivities

12.2.2a Sensory Triggers: Sensory triggers can range anywhere from specific sounds, lights and smells, to temperature and exercise, to triggering content or imagery. Some individuals may be hypersensitive to certain sensory stimuli, experiencing strong, automatic, and involuntary physical or emotional responses to them. Other individuals may be hyposensitive to sensory triggers and may not automatically disengage from harmful stimuli like extreme temperatures or high intensity lights; they may also seek out additional stimulation by using stim toys or other stimulation aids (see Section 12.7). Some common audio triggers are typing; eating; lip smacking; loud, harsh, or sudden sounds; writing with chalk; humming, buzzing or whirring; repetitive sounds like tapping, dripping, or ticking, and many more. Visual triggers include bright lights, bright colors, flashing lights, fluorescent lights, and many more. Common textural triggers are the feel of a pencil on paper or chalk on a chalkboard, the feeling of a chair, light pressures, hard pressures, fabrics, and more. Furthermore, some individuals may be sensitive to certain songs, smells, loud popping or banging noises, tight or restricting spaces, and more. Some individuals may have intense physical reactions to moderately high or low temperatures or exercise — like fainting, panicking (from overactivation of the autonomic nervous system), getting rashes or hives, becoming numb, losing coordination, having seizures, or experiencing severe exhaustion — and some individuals may experience worsened generalized symptom presentation in high or low temperatures. This list of triggers may seem overwhelming to accommodate but remember that here we hope to teach educators how to implement basic, class-wide policies that give students the agency to make appropriate accommodation decisions for themselves. The information presented in this chapter is merely to help the educator understand the reasoning behind the suggested changes in class policy.

Sounds, lights, smells, textures, and potentially triggering content are constantly all around us, and the classroom and lab environments are no different. In addition to many other possible responses, when faced with their sensory triggers in the classroom individuals may experience distress, anger, feel extreme discomfort or a need to fight, flee, or freeze, or they may faint, seize, or become entirely attentionally entrapped by the trigger. In cases where individuals act out of expected proportion to a stimulus (for example, a student suddenly interrupts class by yelling at a classmate for typing too loudly), it is important to remember that these reactions are often not controllable by the individual and outbursts or disruptions are not purposeful and are often immediately regretted by the individual once the involuntary response passes. In the lab, it is extremely important to remember that some individuals may be hyposensitive to sensory stimuli and therefore may be more susceptible to hot or cold burns, cuts, pinches, eye damage from high-intensity light, and more. For example, Class 2 lasers are considered safer than Class 3 lasers in part because it is expected that an individual’s blink reflex would prevent them from directly viewing the beam long enough to exceed the maximum permissible exposure—

however, hyposensitive individuals may have different trigger reflexes than are accounted for in standard safety regulations and therefore may need different or additional personal protective equipment (PPE) than regulation requires.

Examples: Autism Spectrum Disorder (ASD), Migraines, Epilepsy, Obsessive Compulsive Disorder (OCD), Post-Traumatic Stress Disorder (PTSD) or Complex PTSD (cPTSD), Misophonia, Dysautonomia, Multiple Sclerosis (MS), Acquired or Traumatic Brain Injury (ABI or TBI)

Did You Know?

1 in 40 people in the United States are diagnosed with obsessive compulsive disorder (OCD) and it is one of the 20 top causes of illness-related disability in the world,[39] yet it still remains highly misdiagnosed and misunderstood.[40] OCD manifests in many diverse ways, and it has much broader impacts than just what the outside observer can see. Unfortunately, there is a common misconception that an OCD individual is extremely tidy, afraid of germs, or that they engage in repetitive behaviors like turning the lights on and off a set number of times. While some individuals certainly do experience these symptoms and outwards behaviors, this is a stereotypical depiction of the condition, and many do not experience these particular symptoms.[41] At its heart, OCD involves intrusive thoughts, feelings, mental images, urges, or behaviors that are internal in nature, often paired with compulsions meant to relieve the stress and anxiety produced by these thoughts—sometimes these compulsions might manifest externally such that an outside observer may or may not notice, but often they don't—and an outside observer will never be able to tell. Compulsions can be extremely diverse, including things like an existential analysis of one's purpose in life; replaying memories; intense recurrent self-assessments of one's social, work, or academic performance; seeking relationship validation; *etc.* As part of these intrusive thoughts and feelings, many individuals with OCD may also experience perfectionism, a high sense of personal responsibility, social anxiety, difficulty dealing with uncertainty, and more. Academically triggered OCD compulsions may involve erasing and re-writing answers multiple times, checking and re-checking answers, re-reading question prompts, *etc.*

12.2.2b Material Triggers: Here, we use the term material trigger to mean any physical or chemical substance that causes a physical reaction in a person, often involving the immune system. Material triggers can be as diverse as sensory triggers, in terms of both the trigger itself and an individual's response to it. In classroom, lab, and field situations, this could include perfumes; foods (both smelling and ingesting); certain materials like latex or silicone; gloves and other PPE; insect bites, scratches, or stings; certain common laboratory chemical odors; animal dandruff; and grass or tree pollen. When encountering a material trigger, students may have reactions that range anywhere from mild rashes that disappear after a few hours to major incidents that require emergency medical response—and everywhere in between.

Students with material sensitivities may especially be impacted in lab and field environments, where chemicals, PPE, animals, pollen, and insect triggers may be commonly encountered. The number of individuals with life-threatening material sensitivities has been increasing

dramatically since 2004, and 23% of the individuals who required life-saving epinephrine shots in academic settings had no previously known sensitivities or diagnoses. Therefore, educators might find it prudent to proactively learn how to administer epinephrine shots to individuals experiencing life-threatening reactions to material triggers in their classrooms. If students commonly face their material triggers in chemistry labs or classrooms, they may become avoidant of the space, drop the course, or even come to dislike the subject itself—even though they may have extraordinary talent and there are many reasonable accommodations that could help them work safely in the lab. Material triggers may be more commonly experienced in labs that do not have a hood or in classrooms that do not have good ventilation or air quality, especially in the spring. It is important to remember that individuals with chemical sensitivities or intolerances can experience severe reactions at levels of chemical exposure that are typically considered permissible.

Examples: Mast Cell Activation Syndrome (MCAS), Allergies, Asthma, Psoriasis, Chemical Intolerance (CI)

12.2.3 Altered Use of Food, Water, and Restroom

Many disabled or chronically ill individuals may need to drink more fluids, eat frequent snacks, or use the restroom at more frequent intervals than you might anticipate. Others may intake nutrients or expel waste through surgically created ports called stomas. These needs can be due to either a primary or secondary physiological symptom of a condition, can be used as a management strategy to reduce symptom presentation or severity, or can be a side effect of medications. Some individuals may need sudden, unexpected breaks that require them to exit the classroom without warning, while others may be able to plan out and maintain their needs well in advance—and some may have needs that fall in between. The consequences of being unable to take the breaks they need when they need them can include fainting, muscle cramping, excrement accidents or leakage, kidney disease, brain swelling, and comas. Additionally, though stoma port tubing is usually low in profile or taped to their bodies, it is possible for tubing connected to stoma ports to get dislodged — through strenuous activity or by getting caught on objects — requiring anything from a simple reattachment that the individual can do themselves to a major surgical intervention.

Students may need to eat, drink, or take breaks to use the restroom or tend to their stomas in the classroom, especially during long classes or lab periods. These frequent or prolonged breaks may result in them missing important in-class notes or exercises, or they may have less time for labs, tests, or quizzes. If expecting that they will not be allowed to take breaks during class, students may attempt to meet their needs between classes and may therefore occasionally be late to class. If eating during class is permitted, some accommodation conflicts should be expected as some students may have sensory or material triggers related to food, as discussed in Section 12.2.2.

Examples: Diabetes, Dysautonomia, Incontinence, Crohn's Disease or Ulcerative Colitis (UC), Inflammatory Bowel Disease (IBD), Polydipsia, Interstitial Cystitis, Absent Swallow Reflex, Cleft Lip or Palate

12.2.4 Chronic Pain

Chronic pain is a very commonly shared symptom between many illnesses and disabilities, and can also impact energy, attention, and clarity of thought (see Section 12.2.1). Given the commonality of this symptom, many individuals may have multiple coexisting conditions, each of which causes chronic pain. This may cause an increase in the number of painful areas or the types of pain experienced, lead to a snowballing of pain levels, or reduce the ability to manage the symptoms or progression of their conditions. Chronic pain can also lead to disembodiment, where individuals experiencing high levels of pain dampen their connections to their bodies to reduce the degree to which they experience pain. This disembodiment can cause reduced coordination, reduced disengagement from noxious stimuli, or a reduced ability to realize when they've been injured. Chronic pain is not just physical—it can sap energy, attention, and clarity of thought (see Section 12.2.1), it can cause depression and an overwhelming sense of hopelessness, and it can lead to palpable anger, fear, and despair. Even during low-pain periods, or "good days," individuals with chronic pain may feel distrusting of their bodies or anxious about when their pain will get worse and not be fully able to concentrate on the task at hand. As with other dimensions of illness and disability, chronic pain can wax and wane, though it often never fully disappears.

Students experiencing chronic pain may find it difficult to pay attention during class and may frequently get distracted by their pain. Some students may use stim toys to help distract themselves from their pain so that they can focus on other tasks (see Section 12.7). During tests, students experiencing chronic pain may need more time than others to account for time spent managing or bearing their pain, along with the time required to refocus on the question or task at hand. In class, students with chronic pain may need access to standing options, while in the lab students may need plenty of seating. Without appropriate seating or standing options, individuals with pain that is aggravated by their body positioning may make hasty or impatient decisions to simply get through what is required of them so that they can leave and find more accessible spaces. Additionally, individuals experiencing chronic pain may not realize that they have sustained injuries in the lab and therefore may not report it or seek medical attention. In the class, this could result in highly inaccurate assessment scores. In the lab, this could create a potentially dangerous situation both for the student and for others.

Examples: Hypermobility Spectrum Disorder*,* Crohn's Disease or Ulcerative Colitis (UC)*,* Ehlers Danlos Syndrome (EDS)*,* Fibromyalgia*,* Vulvodynia, Multiple Sclerosis, Interstitial Cystitis, Arachnoiditis*,* Migraines, Endometriosis, Rheumatoid Arthritis, Lipedema, Uterine Fibroids, Trigeminal Neuralgia

12.2.5 Atypical Social Interactions

Some illnesses and disabilities can impact the way that individuals interact with other people, or they may be hypersensitive to their social or emotional environments. This can simply be due to having an atypical neurotype, or it can be due to a physiological symptom or from social stigma. Some individuals may have a difficult time recognizing or understanding social queues and therefore may say things or act in a way that is not expected or that neurotypical individuals interpret as disrespectful or strange. Some individuals may become extremely interested in a specific topic and bring it up frequently in conversations with others, while others may get fixated on a specific point of a conversation or problem and interrogate it at length. Some may have a difficult time understanding others' emotions and social queues, while others may be hypersensitive to them. Individuals with social anxiety may experience a range of reactions, anywhere from an elevated heartbeat to temporarily losing vision or fainting, and individuals with traumas may dissociate or have a difficult time being socially present.

Many educators utilize student groups in the classroom and in the lab. Though group work can be important and necessary with limited resources, for individuals with atypical social behaviors, group-forming and group-work processes may be difficult or strained. It may be harder for students to find and join groups, it may be difficult for them to advocate for themselves in group work distribution, or it may be difficult for them to communicate according to expected social traditions. Furthermore, presenting, solving problems, or talking in front of others may be extremely stressful for these individuals, which may cause increased social withdrawal or stress. Though giving in-person presentations is still a major avenue to share scientific results and therefore is often required to progress in the field of chemistry, we recommend that educators still be aware of and accepting of the barriers that some individuals face. When deciding grades for projects that involve substantial social interaction or presentation-style speeches, we recommend that the educator be careful to compartmentalize the student's social performance from their content performance. Practicing typical social behaviors may very well help these students, but receiving grades for their performance may not be helpful or appropriate. In the lab, it may be difficult for students with atypical social behaviors to advocate for their own safety or to correct their lab partners, which could lead to unsafe laboratory conditions.

Examples: Autism Spectrum Disorder (ASD), Post-Traumatic Stress Disorder (PTSD) or Complex PTSD (cPTSD), Anxiety, Tourette's Syndrome, Obsessive Compulsive Disorder (OCD), Acquired or Traumatic Brain Injury (ABI or TBI)

Did You Know?

Impacting 1 in 160 children, Tourette Syndrome (TS) is a common neurodevelopmental condition[42] that affects an individual's disinhibition. It is often not possible to tell that a person has TS, as sometimes their tics look or sound voluntary, or they are very subtle to observers. In other cases, individuals may be able to sometimes suppress their tics and therefore may not consistently express them in class. Sometimes—but not always—the neurological effects of TS can include defiant or disruptive behaviors, which are commonly interpreted by others as excessive sassiness, defiance, or disrespect, even though it is not intentional. As the Tourette Association of America put it, "a sign saying 'Don't Touch, Wet Paint' is an invitation to touch the paint [since] obeying the sign means inhibiting the very behavior suggested by the sign."[43]

12.2.6 Altered Coordination & Strength

Some individuals experience reduced coordination and (or) strength. This may include shaking, tremors, reduced depth perception, low general muscle tone, low grip strength, uncontrolled gripping, difficulty walking, jerky or unstable movements, difficulty speaking, poor balance, and more. These symptoms may be consistent in an individual's life, or they may be reactions to triggers (see Section 12.2.2) or flares (Section 12.2.1) and occur only occasionally. Individuals with reduced coordination or strength may be more prone to dropping, spilling, crushing, or knocking things over, or they may have trouble holding and using precision instruments, including standard pens and pencils.

In the class, students may have difficulty writing or handling model kits. If they have reduced grip strength, shaking, or tremors, they may need more time on tests or other time-based assessments due to difficulty writing legibly. Alternatively, they may wish to use computers in class whenever possible or may prefer recording lectures instead of taking in-class notes. In the lab, lifting solvent bottles or equipment may be difficult, and processes requiring precision movements may require the help of a lab partner or teaching assistant. This might include pouring, titrating, manipulating small amounts of solid reagents, precise alignment of optics, and more. Students with reduced coordination and strength may also need access to ample seating, so that they can focus their cognitive resources on tasks other than standing.

Examples: Multiple Sclerosis, Guillain-Barre Syndrome, Myasthenia Gravis, Chronic Pain, Dysautonomia, Repetitive Stress Injuries, Tendonitis, Dysgraphia, Ataxia, Acquired or Traumatic Brain Injury (ABI or TBI)

12.2.7 Postural Restrictions

For a very diverse number of reasons, many students may not be able to sit or stand for the entire class or lab period, or they may not be able to bend over. When there is no other alternative available to them, sometimes students *can* and *do* stand, sit, or bend in the lab or in class, even though doing so has substantial consequences for their health, aggravates their

condition, or makes it substantially more difficult for them to attend to the task at hand. Therefore, educators should not assume that seeing someone sit or stand for an extended period implies that they are fully able to do so. If unable to move or not move their bodies in whatever way they need, students with postural restrictions may faint, experience intense exhaustion, experience brain fog, dislocate or sublux a joint, tear or sprain ligaments or muscles, experience increased soft tissue swelling or edemas, or experience large fluctuations in their blood pressure—among many other things. Students who are using their bodies in ways that don't work for them may make hasty decisions due to pain or discomfort, resulting in inaccurate assessment scores or potentially dangerous in-lab situations.

Another factor that is extremely important to think about when creating an accessible environment is body size. Though visible, this aspect of diversity is often disregarded in the lab and classroom, creating inaccessible and difficult situations for many students. Substantial weight gain or loss is also a major part of disability and illness, occurring both due to primary and secondary physiological mechanisms and due to medications. Height can also be impacted by disability or illness, resulting in both very tall or very short statures. Special thought should always be given to individuals who are very tall, short, overweight, or thin. Though often severely underrepresented in STEM and higher education due to stigma and bias, educators should expect and plan for larger individuals in their classrooms or labs.

In the classroom and in the lab, students may need to frequently switch between sitting and standing, or they may need to sit or stand the entire time. In the lab, students may not be able to reach items that are on high or low shelving, especially if the object is heavy. Working over a laser table, in a hood, glovebox, or biosafety cabinet, or in a cleanroom may be particularly difficult and require practice beforehand. Any wearable objects like personal protective equipment (PPE) or cleanroom bunny suits should be available in a very wide variety of sizes. Cleanroom bunny suits can be purchased in sizes up to 5XL. Any facility with a cleanroom should ensure that they have multiple sizes available in this range, and anyone with larger bodies or disproportionately larger limbs will need these sizes to be able to complete their work. Tall or overweight individuals may have difficulty fitting in provided seating or PPE, causing injury, pain, or inaccessibility. Short individuals may not be able to reach emergency equipment, phones, drinking fountains, chairs, counters, and more. Thin or short individuals may not have properly fitting PPE available to them, and the loose garments may be hazardous.

Examples: Lymphedema, Plantar Fasciitis, HSD, Dysautonomia, ADHD, Arthritis, Ankylosing Spondylitis, Generalized Back Pain, Arthritis, Lipedema, Postural Orthostatic Tachycardia Syndrome (POTS)

12.2.8 Susceptibility to Injury and Infection

12.2.8a Injury: Many conditions increase an individual's susceptibility to injury. This can be due to tissue weakness or dysfunction, reduced coordination or strength (see Section 12.2.6), impaired healing capabilities, and loss of bodily control, and can lead to an increased risk of cuts; skin, ligament, or muscle tearing; bleeding; bruising; dislocations; subluxations; sprains; bone breaks or fractures; lesions; tissue inflammation; and more. Disabled or ill individuals may also experience slow or impaired healing from injuries once they are sustained, and sustaining a particular injury may lead to recurrent re-injury of the same spot in the future. Without proper supports, the lab may be a particularly dangerous place for these individuals. Without supports or aids, they may not be able to lift heavy objects or apply force to an object—including torque, pulling, or pushing forces—or they may attempt to do them and sustain an injury. Aside from impacting lab procedures, this may also influence emergency response procedures, like using fire extinguishers. Individuals more at risk of injury may more frequently miss class, as they also sustain injuries outside of class that reduce their ability to travel or participate in in-person events. Fingers and hands are commonly impacted by lacerations and joint instabilities or dysfunctions, and thus, in class some individuals may have difficulty with written notes, assignments, or tests.

Joint Subluxation:

An incomplete dislocation of a joint. It can impair movement, balance, and strength.

Examples: Hemophilia, Hypermobility, Seizures, Osteoporosis, Diabetes, Narcolepsy

12.2.8b Infection: Not only are some individuals more prone to injury, but some may be more prone to infection. This may happen in conjunction with an increased risk of injury, or it may not. Some individuals may experience recurrent organ, skin, eye, ear, sinus, or lung infections—which they may or may not be able to pinpoint to a specific cause. These individuals may need to be more careful in avoiding injury or communicable diseases, as infection for them could mean anything from mild cosmetic scarring and discomfort to death. Because of the risk involved in contracting a communicable disease, individuals at higher risk of infection may need to withdraw socially and therefore may be at risk of experiencing profound social isolation. These individuals may also require frequent hospital visits to manage and treat acquired infections, which may also lead to substantial financial hardship.

These individuals may be more likely to miss in-person lectures and labs, especially if they need hospital care or during periods of high community disease transmission, like during the COVID-19 pandemic or flu season. It is important to note that because the risk level is higher for these individuals, current federal, state, local, and institutional pandemic or health guidelines will likely be insufficient for their safety; because of this, they may require more stringent health precautions than what educators may expect or what their academic institution expects to accommodate. Additionally, they may not be able to work with potentially infectious diseases or materials, as the risk assessment for lab work with these materials is elevated.

With any lab work, they may need more protections against cuts, punctures, or scrapes, and therefore may require more comprehensive PPE than what is called for in standard operating protocols.

Examples: Malabsorption, Celiac Disease, Diabetes, Psoriasis, Human Immunodeficiency Virus (HIV), Connective Tissues Disorders, Alcoholism, Arthritis

12.3 Accessibility Guidelines

This book has often discussed official disability accommodations and Americans with Disabilities Act (ADA) requirements. However, given the incredible diversity of disabilities and illnesses along with the many barriers to diagnosis and certification, this chapter will not consider such official accommodations. Instead, here we will outline ways in which educators can broadly alter their teaching, lab, and classroom practices to meet the accommodation needs of every student—whether they are diagnosed or undiagnosed and whether they choose to or are able to report their disability or illness—so that everyone has the tools they need to learn effectively. Remember: accessibility benefits *everyone*. There are many concrete steps that can be taken and policies that can be enacted to make the classroom a more accessible place to learn, which will be discussed in detail in the remaining sections of this chapter. However, before an educator can alter their courses with these concrete changes, it is first helpful to consider and perhaps alter three major components of their teaching philosophy, namely: (1) perspective, (2) expectations, and (3) classroom culture.

The first basic step to achieving an accessible classroom is to readjust perspective. Often, we tend to be more concerned with making sure that we restrict accommodations from people wishing to abuse them than we are with making sure that people who need accommodations *do* receive them. Though it is true that making a classroom more accessible may result in some select students using accommodations they might not actually need, we recommend considering the following perspectives: (1) any student unduly abusing accommodations to minimize how much they have to engage with the course is only doing a disservice to themselves, (2) it is difficult to differentiate between legitimate need and illegitimate accommodation abuse, and (3) since error is unavoidable, a choice needs to be made between erring on the side of providing accommodations to some who may not need them and denying them from some who do. Additionally, it is vital to remember that the accommodations a student needs to participate in an educational program do *not* speak to their compatibility with the field—indeed, it may very well be their strength. For example, individuals with ADHD are less prone to attentional blindness than their neurotypical peers and thus may be more primed to see creative and unexpected solutions.

The second basic step to achieving an accessible classroom is to readjust expectations. As a class becomes more accessible and more respectful of students' abilities and limits, it may happen that there is an unexpectedly large surge in students using the accessible policies.

Though it may be shocking and may require some lesson plan adjustment on the educator's end, a lot of students using these accessible policies does not necessarily signal an abuse or disrespect of the class's accommodations. Students are often overwhelmed and must make prioritizations when their resources are limited by their illness or disability (see Spoon Theory). If they have other professors who are not accommodating at all, they often will have to use their limited resources to meet the inaccessible demands of their other classes—and in some cases, they may have to rely on the accessibility of their other more accessible courses to meet their needs. This does *not* mean that they are taking advantage of their more accommodating courses—rather, it means that they need accommodations and are not receiving them appropriately in their other classes or in other areas of their lives. If this happens, it can be helpful to talk to other colleagues in the institution about their teaching practices and encourage them to also engage in more accessible behavior.

The third basic step to achieving an accessible classroom is to readjust classroom culture. Since the composition of each class will always be different, the most important thing that can be done to create an accessible and respectful environment is to create a classroom environment where students feel comfortable asking for and using accommodations. The wording of a syllabus, the tone used in class, and the way an educator responds to accommodation requests will all contribute to students' perceptions of their class, and ultimately will inform whether they view their educator as someone they can safely ask for help. It is also important to keep in mind that some accommodations may conflict with one another, and the current accessibility policies and practices in a course may be barriers to some of the other students in unexpected ways. We will suggest some strategies later in this chapter for how to avoid some common conflicts, but for now, practice adjusting your perspective by asking yourself: what would you do in the following scenarios?

Scenario A

A student in your class has misophonia but has chosen not to disclose this information to you. In your same class, another student has diabetes and has disclosed to you that they may need to eat small snacks during your class.

> *Misophonia:* A sensory processing disorder where specific innocuous sounds cause intense anger and deep disgust, sometimes accompanied by outbursts. Eating, lip smacking, slurping, and gulping are common misophonia triggers.
>
> *Diabetes:* A chronic metabolic condition that impacts an individual's ability to use glucose as an energy source through an impairment in insulin sensitivity or production. Individuals with diabetes must carefully monitor and control their blood sugar, which often requires them to eat small snacks during the day.

Scenario B

A student in your class has lymphedema and, though they haven't disclosed their condition to you, they frequently stand up and leave the room. In the same class, another student has undiagnosed ADHD and has their attentional momentum broken each time the other student leaves the room. (recorded lectures, standing areas, and easy to leave class)

> *Lymphedema*: A condition of excessive lymphatic fluid accumulation in soft tissues—most commonly in the arms and legs—resulting in potentially severe inflammation, swelling, and pain.
>
> *ADHD:* A neurotype marked by an ongoing pattern of fluctuating attention and increased distractibility. It pay also be accompanied by an increase need for physical movement or stimulation or increased impulsivity.

Scenario C

A student in your class has Postural Orthostatic Tachycardia Syndrome (POTS, a form of dysautonomia) but is undiagnosed. The day before an exam in your class, the student had to stand in line at the DMV, and now they are experiencing post-exertional malaise and their condition is flaring. They feel exhausted, anxious, and their attention is scattered, but they don't know why.

> *POTS:* A type of dysautonomia, where the autonomic nervous system (ANS) malfunctions and has difficulty getting blood to the brain with postural changes. In response to reduced blood flow to the brain upon standing, the ANS drastically changes blood pressure and increases heart rate to force more blood to the brain. In some forms of POTS, the ANS floods the body with androgenic hormones, which may also cause anxiety or panic attacks.

12.4 Classroom Considerations and Adaptations

In the previous section, we detailed various ways in which disabled, or chronically ill individuals interact differently with the world, including ways in which they may experience the classroom or the lab differently than may typically be expected. Here, we will suggest concrete and broad dos and don'ts that educators can apply to their class-wide policies to accommodate many of these students without requiring class-to-class policy changes or requiring that students report their conditions. As was discussed in Section 12.1, many individuals with invisible disabilities or chronic illnesses are not comfortable reporting their conditions, even if their in-class performance would improve with appropriate accommodations. Additionally, chronic illness is complicated, and it often takes decades to get an appropriate diagnosis — many students may not yet understand what is going on with their health, and many more will be unable to furnish any type of official certification of their condition.

Some of these suggested policy changes may be surprising to you, or you may be hesitant to implement them — or perhaps skeptical of how students might use them. If you experience this, we suggest reading Section 12.2 in detail if you haven't already. If you *have* read it and still remain hesitant or skeptical, we encourage you to start engaging with the chronically ill community to learn more directly about their perspectives and experiences. As many disabled and chronically ill individuals must conserve their spoons (Section 12.2.1), disabled communities often form in online spaces, using Twitter and blogging quite heavily.

Dos:

1) ***Use flexible attendance policies with no required proof.*** Giving your students the agency to decide when they can and cannot physically attend class gives them the freedom, they need to make the prioritization decisions that their disability or illness demands of them. When managing a complex illness or disability, this freedom of agency is critical (see especially Sections 12.2.1 and 12.2.8). Since many individuals are undiagnosed or otherwise unable to provide official certification of their condition, putting accommodations behind proof barriers may keep them from individuals in need.

2) ***Provide hybrid options when possible.*** To provide more attendance and participation options for those unable to physically attend class, it is extremely helpful to provide hybrid options when at all possible. Though stressful for all, the institutional responses to the COVID-19 pandemic were revolutionary for many disabled and chronically ill individuals, who for the first time were able to access widespread accommodations that many had previous been told were impossible. Now that we know that it is indeed possible, it's best to maintain hybrid access.

3) ***Use accessible extensions with no required proof.*** Unexpected flares and the need for spoon management mean that disabled and chronically ill students will sometimes be unable to meet strict deadlines (see especially Section 12.2.1). When it is possible, break up large projects into smaller, more manageable chunks. If it is not possible, consider allowing students to turn in partial work by the deadline and amend their work later. Additionally, if possible, ask students about their other classes and try to avoid stacking large projects or important tests with other classes.

4) ***Automatically record all lectures.*** Recording all class lectures and making them available to students is perhaps one of the most impactful things an educator can do to massively boost the accessibility of their classrooms. This one change alone would benefit disabled and chronically ill individuals with altered energy, attention, and clarity of thought (see Section 12.2.1), individuals that need to leave the class frequently due to postural restrictions (see Section 12.2.7), pain (see Section 12.2.4), or altered food, water, and restroom use (see Section 12.2.3), individuals with reduced coordination who find it difficult to take in-class notes (see Section 12.2.6), and anyone who cannot make it to class due to condition-related factors (see especially Sections 12.2.8 and 12.2.2b). To aid in this, instructors may consider using a tablet to write out in-class notes (Wacom, Apple iPads, Microsoft Surface, Samsung Galaxy, etc.) rather than using a chalk or white board. This way, the lecture can be easily recorded using screen capture software and the notes immediately shared online. Instructors should also consider using a lavalier microphone (a fairly cheap and small microphone that clips onto shirts and can be plugged into cellphones or tablets) to ensure clear audio quality. If students ask questions in class, the instructor should repeat the question asked both for the recording and for other students in class who may not have been able to hear the question. This is the best solution to ***Scenario B***. By recording lectures, both the student leaving class and the student distracted by them would have access to the lecture material that they missed.

5) ***Allow respectful and responsible use of personal computers in the classroom.*** Responsible computer use in the classroom can help disabled or chronically ill students take notes, access assistive technology, and prepare study materials. It can also open up an entire world of rich educational content for the educator to utilize creatively in class. Personal computers may be a source of distraction for some with scattered attention (see Section 12.2.1) but recording class lectures (see number 4) and asking that your students use their judgement and turn off their internet if they need to may help. To accommodate others, it is best to ask students using computers to mute their devices and to turn the screen brightness as low as they can while still being able to see their screens.

6) ***Allow food in class in a designated area***. By designating food-free and food-friendly areas of the room explicitly, you can accommodate both individuals with disabilities or

illnesses that may require them to eat in your course (Section 12.2.3) as well as individuals with sensory processing disorders or material sensitivities (Section 12.2.2) who may not be able to be near eating individuals. Critically, this approach also does not require students to disclose their condition, which they may want to keep private, or they may not have yet defined. Allowing food and drink in the classroom in *pre-designated areas* is the best solution to ***Scenario A***, accommodating the student who needs to eat in class and allowing the student with trigger sensitivities to sit far enough away from food areas.

7) ***Make lecture notes available to students, both before and after lecture.*** When at all possible, making all written lecture notes available to students at the beginning of the quarter or semester gives students flexibility in how they interact with the course. Some may learn best by studying the notes before lecture, some may prefer to print the notes out and annotate them during class instead of copying notes, and others may prefer to just be present during class and look at the provided notes later.

8) ***Provide alternate options for desks and seating.*** Students with disabilities or chronic illnesses may benefit a great deal from a range of diverse seating or standing options (see especially Sections 12.2.1, 12.2.4, 12.2.6, and 12.2.7). In particular, providing tall tables without chairs for students to stand at and free-standing chairs without arm rests that aren't connected to desks are important. We recognize that this accommodation may be difficult for individual educators to enact, so we encourage educators to bring these issues up with their disability accommodations office or their departmental or institutional leadership.

9) ***Encourage and use informal office hours.*** Not only are office hours a fantastic way to get to know your disabled and chronically ill students and get familiar with their needs, they are also a wonderful tool for any of your students who may have atypical social interactions (Section 12.2.5). By using office hours, educators can keep their lectures streamlined, engage students with deep special interests, and give students with social anxieties a chance to ask questions. However, it is important to remember that often many students feel afraid to utilize office hours, or they hold a common misconception that utilizing office hours means that they have failed. To overcome this, it can help to hold office hours in a more neutral location, rather than in the educator's office.

Don'ts:

1) ***Use participation points.*** There are a great many reasons why disabled or chronically ill students may not actively participate in class to the degree that the educator might be expecting (see especially Sections 12.2.1, 12.2.4, and 12.2.5). Because of this, we highly recommend that educators do not use participation points. However, if participation points are for some reason unavoidable, we recommend that educators

give students a variety of choices for obtaining the points, such as speaking in class, submitting written materials, drawing pictures, etc.

2) ***Require hand-written in-class notes.*** Students may be physically unable to copy notes in class (Section 12.2.6), or they may have trouble absorbing the content of the lecture while also copying notes (Section 12.2.1). Thus, we recommend that educators do not require students to do so, either explicitly through classroom policy and calling out students or implicitly through not making classroom notes attainable through other means.

3) ***Assign points to social performance or group-dependent performance.*** Since many students may have difficulties with social interactions to varying degrees and valences due to their disability or illness (see especially Sections 12.2.1, 12.2.4, and 12.2.5), we recommend that educators refrain from assigning grades or points to social performances. Though it is true that public presentations and group interactions are important to progressing in the field of chemistry, we recommend that educators simply help their students practice, rather than grade their performance. Thus, for presentations or group-dependent performances, we recommend that educators compartmentalize a student's social performance from their content performance. Educators can make private comments or suggestions for improvement without tying it to their grades.

12.5 Testing

Dos:

1) ***Provide a favorable testing environment.*** Though not always within the control of educators, understanding and considering testing environments may help educators better understand their students' test-taking experiences. Are there any humming, buzzing, or whirring noises? What about repetitive clicking, tapping, or ticking noises? Are there harsh fluorescent lights, and are any of them flickering? All of these things can interact with students' disabilities or illnesses and make it more difficult for them to focus on their test (see especially Section 12.2.2a). If the educator is unable to change the testing environment, it may be helpful to allow students to use noise cancelling headphones, listen to music, wear sunglasses, or otherwise allow them to take their sensory input into their own hands.

2) ***Allow students to use the instruments of their choice.*** Allowing students to use the writing instrument of their choice again simply gives the student the power to make sensory-input decisions for themselves. Some students may have very visceral reactions to using pencils, and if required to do so may write as little as possible or may have a lot of their cognitive resources taken up by sensory processing (see especially

Section 12.2.2a). Additionally, some students may get a substantial benefit from using stim toys in class or during tests (see Section 12.7). If at all possible, the educator should allow students to use whatever sensory stimulation aids they deem necessary for themselves. Since these have the potential to be distracting to other students, however, the educator should set some ground rules for their use early in the course. In particular, the educator should ask students to aim for stim toys that are small in profile, are quiet, and don't require large bodily movements to use.

3) ***Allow makeup tests or drop the lowest grade if at all possible.*** Many educators might be hesitant to enact a broad policy allowing makeup tests—and we certainly understand why. Passing along information about assignments and tests is not a rarity amongst students, unfortunately. However, disabled or chronically ill students may frequently miss class or simply be unable to conjure up the cognitive resources to dedicate to a test. There are many reasons for this, including flares, spoon management (see Section 12.2.1), risk management, injury, infection (see Section 12.2.8), hospitalization, and more. Therefore, we recommend that educators consider how to modify their assessment structure so that disabled and ill students are appropriately accommodated. If pure makeup tests are not possible, we recommend at least dropping the lowest exam score. Alternatively, educators can design take-home open-note assessments, slightly alter the question format of makeup tests, or slightly delay returning graded assessments to allow for makeup tests to be finished. Though none of these solutions are perfect at deterring information-sharing, they certainly reduce the impact enough to allow for appropriate accommodations. This is the best solution to ***Scenario C****.* Giving the student enough time to recover before taking the test — or at least dropping the lowest test score—would result in the most accurate representation of the student's knowledge.

4) ***Get creative with your assessments.*** Though it might be hard to envisionanything different at first, there are many alternatives to written, timed, in-class tests—and we highly encourage educators to play around and try to develop new assessment tools. Using different types of assessments may bring out strengths in some students that are often hidden in test-based written assessments and therefore contribute to more accurate assessment data.

Don'ts:

1) ***Design tests to take the entire class period.*** Are you interested in testing for the underlying trait of how fast a student can process information? If not, standard testing styles are likely biasing results. To get an accurate picture of how well students understand the material, they should not be heavily crunched for time. When first designing a course, it is best practice create a test which has erred on the side of being too short, then adjust the length from there. Consider that people with ADHD

may have to spend time getting back into the moment (see Section 12.2.1b), people with OCD may repeatedly read questions or erase and rewrite their answers (see Section 12.2.2a), people with ME may be experiencing brain fog and find it difficult to form thoughts (see Sections 12.2.1a and 12.2.1c), people with chronic pain (Section 12.2.4) or postural restrictions (Section 12.2.7) may need to take mental or physical breaks to manage their bodies, etc. This is another solution to ***Scenario C***. Designing a test that includes accessibility accommodations would help this student by giving them more time to form their thoughts, solve problems, and read questions. With brain fog, this extra time will result in a much more accurate picture of the student's actual understanding of the content.

2) ***Forbid calculators.*** Are you interested in testing for the underlying ability of being quick and accurate at mental math? If not, we highly encourage educators to allow students to use calculators. Many individuals work best by offloading cognitive resources onto the environment, especially (but not only) disabled and chronically ill individuals (see especially Section 12.2.1). Without a calculator, this means using a significant amount of time and energy writing down tangentially related calculations. In a seasoned career as a chemist, most individuals will have ample access to calculators, equations sheets, reference information, and more. We recommend taking this into consideration and therefore avoid testing for rote memorization or mental math abilities when at all possible. We recognize that in high school settings especially this may not be possible as educators must prepare students for upcoming standardized assessments, the format of which is out of their control. However, when at all possible or reasonable, we suggest allowing calculators and reference sheets to better capture students' knowledge, understanding, and critical thinking.

12.6 Laboratory Considerations and Adaptations

Dos:

1) Allow students to keep an electronic notebook. Electronic notebooks are great for a variety of reasons. Not only do they benefit many disabled and chronically ill students (see especially Section 12.2.6), but they also save paper, reduce chemical contamination, save time, result in notebooks with richer content, reduce cost to the student, and open up useful features like searching and automated indexing. Students may use audio recordings, use speech-to-text typing, take pictures, create graphs, and more. However, it is important to talk to students beforehand to make sure that appropriate rules regarding computer use in the lab are followed. Students should make sure to never touch their computers with gloves on, and they should keep their computers on an uncontaminated, chemical-free surface. To reduce chemical contamination, this should also be done when using physical lab notebooks.

2) ***Use chemical hoods whenever possible.*** Some disabled and ill individuals avoid the subject of chemistry because they have intense reactions to material triggers in the laboratory (Section 12.2.2b). Though we realize that many educational lab spaces are not equipped with hoods, we encourage anyone who has access to hoods to always use them — even when working on the bench would be acceptable. Alternatively, if only a few hood spaces are available, we encourage educators to keep solvent and waste bottles in a hood, saving the rest of the hoods for individuals with known material sensitivities.

3) ***Provide seating options.*** As in the classroom, it is important that all lab settings have appropriate seating and standing options. For individuals with reduced coordination (Section 12.2.6), reduced energy (Section 12.2.1a), chronic pain (Section 12.2.4), postural restrictions (Section 12.2.7), and more, having access to appropriate seating not only helps them physically but also frees up the mental resources needed to work safely in the lab. Without appropriate access to seating, disabled or ill students might make hasty decisions or rush through the lab procedure simply because their body has needs that aren't appropriately being met.

4) ***Pre-record a demonstration of the experiment.*** For those who couldn't finish the procedure or who didn't get the expected result, having a recording of a successful experiment ensures that students have the same access to educational information. If part of the lab involves analysis or use of a compound that they were supposed to obtain in an earlier part of the procedure, it may also be helpful to have a stock of pre-made samples available for students to use if they weren't able to get the desired result in time. Not only is this helpful for many disabled and ill students, it's helpful for everyone.

5) ***Have a couple of pairs of cut-resistant gloves, carts, and trays available for anyone to use.*** Since some disabled or ill students may be at higher risk of injury and infection (Section 12.2.8), lab instructors should always ensure that a pair or two of cut resistant gloves are always available. Additionally, for students with altered coordination or strength (Section 12.2.6), carts and trays can help them move instruments, glassware, reagents, solvents, and more to their workstations safely.

Don'ts:

1) ***Require students to hand-copy lab procedures from lab manuals.*** Though it is a fairly common practice to require students to copy the lab procedure from a lab manual into their carbon-copy lab notebooks, we recommend that educators re-evaluate this practice. Aside from taking up a lot of students' time and providing little educational benefit, this practice may also be particularly difficult for individuals with chronic pain (Section 12.2.4) or altered coordination or strength (12.2.6). Instead, we recommend an approach centered on autonomy, guided inquiry, and peer-to-peer engagement. See

particularly the 2022 report by Williams and Driers on the construction and evaluation of such a course.

2) ***Assume that appropriately sized PPE is available or rely on students to request appropriate sizes.*** It is extremely important to have appropriately sized PPE for all students available on day one of the lab course. Educators should not guess students' sizes by looking at their bodies, and they also should not rely on individual students coming forward to report that there is not a correct size for them in the provided PPE. This can be an extremely daunting prospect for students, especially if they inhabit a stigmatized body and the request must be made in a public manner, such as during the first day of lab. A broad range of lab coat sizes should be available at all times, with more than one option readily available without special request up to 6XL and down to XXS, which are readily available from lab coat manufacturers. Students should not have to report their sizes to receive PPE; instead, allow them to simply pick what they need on their own.

3) ***Rely on lab partners to keep unsafe behavior in check.*** Individuals with atypical social interactions particularly may have a difficult time advocating for themselves in unsafe lab situations (see Section 12.2.5). Aside from the educator keeping a close eye themselves on the safety behavior of their students in the lab, educators can also help create a safer lab environment by maintaining an approachable demeanor such that students with social anxiety or atypical social behavior knows that they can safely ask their educator for help in unsafe lab situations.

12.7 Assistive Technology

1) ***Personal computers.*** Personal computers can open up a whole new world of accessibility for your students. Giving students the agency to use rich tools like these can make an incredible difference when it comes to managing energy, time, and other resources that are precious to disabled and ill students. With personal computers, students can generate searchable and indexed notes, use speech-to-text features to quickly make notes, link to helpful online resources, cross-reference topics, and more—all while maintaining access to traditionally pen-and-paper-only benefits, like complex graph drawing, easy equation input, and more.

2) ***Stim toys.*** Self-stimulation toys, or "stim toys" for short are objects that provide sensory stimulation which can be used to focus attention, ease symptom presentation, center oneself, or otherwise aid an individual in the self-management of their cognitive or behavioral resources. Frequently, these objects have tactile components which allow for textural or motor stimulation, though sometimes they include auditory or visual stimulation as well. Some students may fidget with objects commonly found in classrooms in lieu of using formal stim toys, like twirling pens between their fingers or

squeezing eraser blocks. To avoid distracting others in the classroom, we recommend that students try to use smaller, quieter stim toys which don't require large bodily movements.

Figure 2. **Three examples of stim toys. Images reprinted with permission from Ashley Lauren Spencer, the founder of The Autistic Innovator Shop, an online store that specializes in creating high-quality stim toys for adults** (https://shop.autisticinnovator.com/).

3) ***Speech to text and text to speech.*** Converting reading materials to audio using text to speech software like NaturalReader can have enormous benefits for many disabled or ill students (see especially Section 12.2.1). If it's possible, pre-converting the reading materials and providing both the text and the audio formats to students is recommended. However, if the educator is not able to do so, simply making the students aware of such software may be extremely helpful. Additionally, when it comes to writing lab reports or other text-heavy assignments, speech to text software like Converse Smartly may help students. From the educator's perspective, again simply informing students of the software is beneficial.

4) ***Writing tablets.*** Though students can and do use tablet technology to take notes in classes where computers are permitted, the educator can also take advantage of this technology to provide more accessible information to their students while minimizing additional workload on themselves. By using a tablet like Wacom, Samsung Galaxy, Microsoft Surface, and more to write through class lectures instead of a chalkboard or white board, educators can easily record the lecture presentation with high fidelity and share it with students, with almost no extra work on the educator's part. Additionally, because these tablets reduce the need for educators to stand at chalkboards all day, these tablets may also help meet accessibility needs of educators themselves! It can't be said too many times: accessibility benefits everyone.

12.8 Acknowledgements

Thank you greatly to all of the members of the disabled and chronically ill community who made this piece possible. Thank you specifically to Flame, Tangie, Et Alia, Morgan, and Keely who shared their personal stories of being disabled and chronically ill in academia and who gave me invaluable feedback on this chapter. Thank you to the NEISVoid community for embracing me in my journey with chronic illness and for teaching me how to be more respectful of my limitations. And finally, thank you to Professor Cheryl Richardson at the Center for College Teaching at the University of Chicago, who taught the only truly accessible course I have ever taken and who taught me that we can indeed do things differently—and learn a hell of a lot in the process.

12.9 References

1. WHO. Disability and Health. *WHO*, 2021. https://www.who.int/news-room/fact-sheets/detail/disability-and-health (accessed 2020-07-21)

2. The Lancet. Tackling the burden of chronic diseases in the USA. *Lancet* **2009**, *373* (9659), 185.

3. CDC. The Power of Prevention. *CDC,* 2023. https://www.cdc.gov/chronicdisease/programs-impact/pop/covid-19.htm (accessed 2020-07-21)

4. CDC. Disability and Health Data System (DHDS). *CDC*, 2022. https://dhds.cdc.gov/SP (accessed 2020-07-21)

5. Okoro, C.A.; Hollis, N.D.; Cyrus, A.C.; Griffin-Blake, S. Prevalence of Disabilities and Health Care Access by Disability Status and Type Among Adults—United States, 2016. *Morb. Moral. Wkly. Rep.* **2018**, *67* (32), 882–887.

6. HealthSparq. *2022 Annual Consumer Sentiment Benchmark Report: The State of Healthcare Transparency and Health Plan Member Engagement*, 2022. https://go.healthsparq.com/hubfs/White%20Papers/Gated/2022%20HealthSparq%20Consumer%20Benchmark%20Report.pdf?utm_campaign=2022-05_2022%20Benchmark%20Campaign&utm_source=BusinessWire&utm_medium=PR (accessed 2020-07-21)

7. Hubbell, F.A.; Waitzkin, H.; Rucker, L.; Akin, B.V.; Heide, G. Financial Barriers to Medical Care: A Prospective Study in a University-Affiliated Community Clinic. *Am J. Med. Sci.* **1989**, *297* (3), 158–162.

8. Jelani, O-U-A.; Jhamnani, S.; Spatz, E.; Spertus, J.; Smolderen, K.; Wang, J.' Desai, N.; Jones, P.G.; Gosch, K.L.; Shah, S.M.; Attaran, R.; Mena-Hurtado, C. Financial barriers in accessing medical care for peripherial artery disease are associated with delay of presentation and adverse health status outcomes in the United States. *Vasc. Med.* **2019**, *25* (1), 13–24.

9. Vargas, I.' Mogollón-Pérez, A.S.; De Paepe, P.; da Silva, M.R.F.; Unger, J.-P.; Vázquez, M.-L. Barriers to healthcare coordination in market-based and decentralized public health systems: a qualitative study in healthcare networks of Colombia and Brazil. *Health Policy Plann.* **2016**, *31* (6), 736–748.

10. Harrison, S.; Nekhlyudov, L.; Bell, D.; Bowdage, S.; Nicholson, B. D. Bridging the gap between care: is speed dating the answer? *Br. J. Gen. Pract.* **2020**, *70* (691), 73.

11. Allen, E.M.; Call, K.T.; Beebe, T.K.; McAlpine, D.D.; Johnson, P.J. Barriers to Care and Healthcare Utilization among the Publicly Insured. *Med. Care.* **2017**, *55* (3), 207–214.

12. Ewing, E. Weight bias and stigmatization: what is it and what can we do about it? *Br. J. Gen. Pract.* **2019**, *69* (684), 349.

13. Knaak, S.; Mantler, E.; Szeto, A. Mental illness-related stigma in healthcare: Barriers to access and care and evidence-based solutions. *Healthcare Manage. Forum* **2017**, *30* (2), 111–116.

14. Krier, S.; Bozich, C.; Pompa, R.; Friedman, M.R. Assessing HIV-Related Stigma in Healthcare Settings in the Era of the COVID-19 Pandemic, Pittsburgh, Pennsylvania. *AIDS Behav.* **2020**, *24*, 2483–2485.

15. Fraser, S.; Moore, D.; Farrugia A.; Edwards, M.; Madden, A. Exclusion and hospitality: the subtle dynamics of stigma in healthcare access for people emerging from alcohol and other drug treatment. *Soc. Health Illness* **2020***, 42* (8), 1801–1820.

16. Scott, B.E. Racial and ethnic equality is also about healthcare. *AJHP* **2021**, *78* (6), 523–524.

17. Tabaac, A.R.; Solazzo, A.L.; Gordon, A.R.; Austin, B.; Guss, C.; Charlton, B.M. Sexual orientation-related disparities in healthcare access in three cohorts of U.S. adults. *Prev. Med.* **2020***, 132*, 105999.

18. Mahendraraj, K.; Sidhu, K.; Lau, C.S.M.; McRoy, G.J.; Chamberlain, R.S.; Smith, F.O. Malignant Melanoma in African-Americans. *Medicine* **2017**, *96* (15), e6258.

19. Papier, A. To begin addressing racial bias in medicine, start with the skin. *STAT*, 2020. https://www.statnews.com/2020/07/20/to-begin-addressing-racial-bias-in-medicine-start-with-the-skin (accessed 2020-07-21)

20. Hoffman, K.M. Trawalter, S. Axt, J.R., Oliver, M.N. Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between blacks and whites. *Psychol. Cognit. Sci*. **2016**, *113* (16), 4296–4301.

21. Safer, J.; Coleman, E.; Feldman, J.; Garofalo, R.; Hembree, W.; Radix, A.; Sevelius, J. Barriers to healthcare for transgender individuals. *Curr. Opin. Endocrinol. Diabetes Obes.* ***2016***, *23* (2) 168–171.

22. Wen, L. Doctors' Ignorance Stands in the Way of Care for The Disabled. *NPR*, 2014. https://www.npr.org/sections/health-shots/2014/05/17/313015089/doctors-ignorance-stands-in-the-way-of-care-for-the-disabled/ (accessed 2020-07-21)

23. Su, T.; Hamwi, K. Why Has My Doctor Not Heard of Lipedema? *Art Lipo Plastic Surgery*, 2021. https://artlipo.com/general/why-has-my-doctor-not-heard-of-lipedema/ (accessed 2020-07-21)

24. Ashley, S. Your Doc Doesn't Know Sh*t About This System Failure. *Medium*, 2022. https://medium.com/honestly-yours/your-doc-doesnt-know-sh-t-about-this-system-failure-bf83a772aa27 (accessed 2020-07-21)

25. Spillmann, R.C.; McConkie-Rosell, A.; Pena, L.; Jiang, Y-H.; Undiagnosed Diseases Network; Schooch, K.; Walley, N.; Sanders, C.; Sullivan, J.; Hooper, S.R.; Shashi, V. A window into living with an undiagnosed disease: illness narratives from the Undiagnosed Disease Network. *Orphanet J. Rare Dis*. **2017**, *12* (71), 1–11. https://ojrd.biomedcentral.com/articles/10.1186/s13023-017-0623-3 (accessed 2020-07-21)

26. Komaroff, A.L.; Bateman, L. Will COVID-19 Lead to Myalgic Encephalomyelitis/Chronic Fatigue Syndrome? *Front. Med.* **2021**, 7, 606824.

27. Griffith, J.; Zarrouf, F.A. A Systematic Review of Chronic Fatigue Syndrome: Don't Assume It's Depression. *Primary Care Companion J. Clin. Psychiatry* **2008**, *10* (2), 120-128.

28. Coqal. *Disabilities and Inclusion*, 2017. https://coqual.org/reports/disabilities/and/inclusion/ (accessed 2020-07-21)

29. Aimone, L. Living Under the Stigma of an Invisible Illness. *Distorted Perceptions*, **2019**. https://refocuslookagain.org/articles-main/2019/11/17/living-under-the-stigma-of-an-invisible-illness (accessed 2020-07-21)

30. Miserandino, C. Spoon Theory. *ButYouDontLookSick.com*, 2003. https://butyoudontlooksick.com/articles/written-by-christine/the-spoon-theory/ (accessed 2020-07-21)

31. Cleveland Clinic. Fatigue. *Cleveland Clinic*, 2020. https://my.clevelandclinic.org/health/symptoms/21206-fatigue (accessed 2020-07-21)

32. Garg, H.; Bush, S.; Gappmaier, E. Associations Between Fatigue and Disability, Functional Mobility, Depression, and Quality of Life in People with Multiple Sclerosis. *Int. J. MS Care* **2016**, 18 (2), 7177.

33. Kluger, B.M.; Krupp, L.B., Enoka, R.M. Fatigue and fatigability in neurologic illnesses. *Neurology* **2013**, *80* (4), 409–416.

34. Pearson, E.J. Fatigue—a substantial problem in hematology, but what can be done? *Leuk. Lymphoma* **2021**, *63* (2), 263–264. DOI: 10.1080/10428194.2021.1992767 (accessed 2020-07-21)

35. CDC. *Autism Spectrum Disorder (ASD)*, 2022. https://www.cdc.gov/ncbddd/autism/data.html (accessed 2020-07-21)

36. Bargiela, S., Steward, R., Mandy, W., The Experiences of Late-diagnosed Women with Autism Spectrum Conditions: An Investigation of the Female Autism Phenotype. *J. Autism Dev Disord.* **2016**. *46*(10), 3281-3294.

37. Lai, M-C., Baron-Cohen, S. Identifying the lost generation of adults with autism spectrum conditions. *Lancet Psych.* **2015**. *2*(11), 1013-27.

38. Seymore, A. The Different Ways Brain Fog Affects All Aspects of My Life. *The Mighty*, 2017. https://themighty.com/topic/chronic-illness/chronic-illness-what-its-like-to-have-brain-fog/ (accessed 2020-07-21)

39. BeyondOCD.com Facts about Obsessive Compulsive Disorder. *BeyondOCD.org,* 2019. https://beyondocd.org/ocd-facts (accessed 2020-07-21)

40. Stahnke, B.A systematic review of misdiagnosis in those with obsessive-compulsive disorder. *J Affective Disord. Rep.* **2021**, *6*, 100231.

41. NOCD. A Quick Guide to Some Common OCD Subtypes. *NOCD*, 2021. https://www.treatmyocd.com/blog/a-quick-guide-to-some-common-ocd-subtypes (accessed 2020-07-21)

42. CDC. Tourette Syndrome (TS). *CDC*, 2022. https://www.cdc.gov/ncbddd/tourette/data.html (accessed 2020-07-21)

43. Giordano, K.J.; Edelman, M. Understanding Behavioral Symptoms in Tourette Syndrome. *Tourette Association of America*, 2018. https://tourette.org/resource/understanding-behavioral-symptoms-tourette-syndrome/ (accessed 2020-07-21)

In Conclusion

With increasing attention to DEIR (Diversity, Equity, Inclusion, and Respect) concerns, the history of science is actually making a comeback into our high school and college classes, pointing out the diversity of those who have contributed in the past and who are currently forging new ground in the sciences. Some names you have known all of your professional life; others are possibly new to you. Consider some individuals in a wide variety of STEM fields. Solomon Lefschetz was a mathematician best known for his work on non-linear ordinary differential equations and the topological aspects of algebraic geometry. Wilhelm Bunsen discovered cesium and ruthenium, advanced the science of spectral analysis of the elements, and of course developed the laboratory burner named for him. Sara Rankin is Professor of Leukocyte and Stem Cell Biology at Imperial College London, currently working on regenerative pharmacology. K. Renee Horton is a physicist and NASA engineer. Hamied Haroon conducts research in biomedical MRI, focusing on changes in the brain's microstructure as a result of dementia. Geerat Verneij is an evolutionary biologist studying extinct species and their predators. Thomas Edison's work resulted in over a thousand U.S. patents for diverse products such as the phonograph, light bulb, and motion picture camera. Florence Seibert's work led to making intravenous and blood transfusions safer during surgery, as well as developing the standard test for tuberculosis.

Why would these names come up in a book discussing teaching students with disabilities? Each of these men and women had a disability. Solomon Lefschetz had both hands and forearms amputated as a result of an accident. Wilhelm Bunsen analyzed spectra of heated metals even though a lab accident left him blind in one eye. Sara Rankin realized at the age of 47 that her difficulties in reading and writing were the result of dyslexia and dyspraxia. K. Renee Horton is deaf. Hamied Haroon has a progressive hereditary neurological condition that has left him a quadriplegic. Geerat Verneij has been blind since birth. Florence Siebert had a mobility impairment as a result of childhood polio.

Too often, students with disabilities are discouraged from pursuing careers in STEM. Our hope as authors is that you will find information in this book to enable every student to receive the help, they need to pursue their dreams. Some will continue in chemistry or another STEM field; others will transition to a different career but will still have experienced the challenge and joy of participating fully in the science we love.

RESOURCES

PROFESSIONAL ASSOCIATIONS

American Chemical Society

https://www.acs.org/ (accessed 2020-07-21)

One of the four ACS Core Values is Diversity, Equity, Inclusion, and Respect. The society is committed to making its regional and national meetings and specialty conferences accessible to persons with disabilities. Upon advance request, accommodations will be made for housing and for attendance at technical sessions and meeting special events.

American Chemical Society Committee on Chemists with Disabilities

https://www.acs.org/cwd (accessed 2020-07-21)

The mission of the ACS Committee on Chemists with Disabilities is to "promote educational and professional opportunities in the chemical sciences and in fields requiring knowledge of chemistry for persons with disabilities. The committee will champion the capabilities of those persons to educators, employers, and peers."

American Association for the Advancement of Science

http://www.aaas.org/ (accessed 2020-07-21)

AAAS also has a long-time commitment to making all of its meetings and conferences accessible to people with disabilities. Every AAAS annual meeting has a Resource Room for registrants with disabilities as well as some events specifically geared to scientists with disabilities. The AAAS Project on Science, Technology and Disability was founded in 1975 to allow people with disabilities better opportunities to advance in science, mathematics, and engineering. Primarily an information center, the project links people with disabilities and their families, professors, teachers, and counselors with scientists and engineers who can share their education and career coping strategies in technical fields. AAAS manages EntryPoint! (https://www.aaas.org/programs/entry-point), a program to recruit and counsel undergraduate and graduate students with disabilities majoring in science or engineering and place them in paid summer internships with NASA, NSF, IBM, and other technical companies in the private sector.

Association on Higher Education and Disability

www.ahead.org (accessed 2020-07-21)

AHEAD is an international association of disability support service offices from morethan 600 institutions of higher learning. Although not devoted specifically to science education, AHEAD offers many resources for those at the postsecondary level.

National Council on Disability

www.ncd.gov (accessed 2020-07-21)

NCD is an independent federal agency charged with advising the President, Congress, and other federal agencies regarding policies, programs, practices, and procedures that affect people with disabilities. NCD comprises a team of Presidential and Congressional appointees, an Executive Director appointed by the Chair, and full-time professional staff.

National Easter Seal Society

https://www.easterseals.com/ (accessed 2020-07-21)

This organization provides information and referral services related to assistivetechnology and will direct persons to appropriate Easter Seal Society affiliates.

National Organization on Disability

www.nod.org (accessed 2020-07-21)

NOD promotes the full and equal participation of America's 54 million men, women, and children with disabilities in all aspects of life. NOD was founded as an outgrowth of the United Nations Year of Disabled Persons. NOD is the only national network organization concerned with all disabilities, all age groups, and all disability issues. NOD's seven major programs are the Community Partnership Program, the National Organization Partnership Program, the CEO Council, the Start on Success Student Internship Program, the Religion and Disability Program, the Attitudinal Surveying Program, and the World Committee on Disability.

National Science Teachers Association

www.nsta.org (accessed 2020-07-21)

NSTA is a national association that subscribes to the importance of equal access toscience education for students with exceptionalities. NSTA has published a

positionstatement on Students with Exceptionalities (PositionStatement_Exceptionalities.pdf).

Office of Special Education and Rehabilitative Services
https://www2.ed.gov/about/offices/list/osers/index.html?src=mr (accessed 2020-07-21)

This federal agency answers questions about services and programs for individuals of all ages with disabilities. The agency has three components: the Office of Special Education Programs; the Rehabilitation Services Administration, which oversees programs that help individuals with physical or mental disabilities to obtain employment; and the National Institute on Disability and Rehabilitation Research, which provides leadership and support for a comprehensive program of research related to the rehabilitation of individuals with disabilities.

RESOURCES FOR REHABILITATION

www.rfr.org (accessed 2020-07-21)

This organization publishes resource guides that enable individuals with disabilities and those who work with them to locate organizations, assistive technology, and publications that contribute to independence in the workplace and home. Publications cover the most prevalent disabilities and conditions, including visual impairment, hearing impairment, back pain, spinal cord injury, diabetes, multiple sclerosis, arthritis, and epilepsy. Titles include *Meeting the Needs of Employees with Disabilities* and *Resources for People with Disabilities and Chronic Conditions*. A multidisciplinary faculty is available to conduct custom-designed training programs, research projects, and evaluations.

World Institute on Disability

www.wid.org (accessed 2020-07-21)

This institute is a public policy center that conducts research, public education, and training; it also develops model programs related to disability. It deals with issues such as public transportation, employment, and health care.

JOURNALS

Journal of Chemical Education
https://pubs.acs.org/journal/jceda8 (accessed 2020-07-21)

Journal of Postsecondary Education and Disability
https://www.ahead.org/professional-resources/publications/jped (accessed 2020-07-21)

Journal of Science Education for Students with Disabilities
https://scholarworks.rit.edu/jsesd/ (accessed 2020-07-21)

BOOKS

Disability, Visibility: First-Person Stories for the Twenty-First Century

By Alice Wong (ISBN-10: 1984899422, ISBN-13: 978-1984899422)

This anthology gives a glimpse into the rich complexity of the disabled experience, highlighting the passions, talents, and everyday lives of this community.

Job-Hunting Tips for the So-Called Handicapped or People Who Have Disabilities, 2nd ed.

By Richard Nelson Bolles and Dale Susan Brown (ISBN-10: 1580081959, ISBN-13: 978-1580081955)

This is a supplement to the popular job-hunting handbook, *What Color is Your Parachute?* To order, contact Ten Speed Press, https://crownpublishing.com/archives/imprint/ten-speed-press. (accessed 2023-07-21)

Job Strategies for People with Disabilities

By Melanie Astaire Witt (ISBN-10: 1560791438, ISBN-13: 978-1560791430).

Advice is offered on job hunting, resume preparation, the job interview, career planning, your rights in the workplace under the ADA, when to disclose your disability to a potential employer, and other topics.

K & W Guide to Colleges for the Learning Disabled, 15th ed.

By Marybeth Kravets and I. F. Wax (ISBN-13: 978-0525570301, ISBN-10: 0525570306)

Published by Princeton Review, this is a comprehensive guide for students, families, and guidance counselors to determine the best college for students with learning differences.

Safety in Academic Chemistry Laboratories

https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf (accessed 2023-07-21)

Published by the ACS Committee on Chemical Safety, this book highlights best practices for first- and second-year university students.

Teaching Adolescents with LD: Strategies and Methods

By Donald D Deschler, Edwin S. Ellis, and B. Keith Lenz (ISBN-13: 978-0891082415, ISBN-10: 0891082417)

Published by Love Publishing Company, this book offers the instructional approach that emphasizes thinking processes, self-regulation, and problem solving. The text presents a range of general strategies that can be applied to various content areas. It contains information on memory, note-taking, test-taking, social skills, transition, and collaborative skills.

Working Chemists with Disabilities: Expanding Opportunities in Science
https://www.amazon.com/Working-Chemists-Disabilities-Expanding-Opportunities/dp/0841235023 (accessed 2023-07-21)

Published by the ACS Committee on Chemists with Disabilities, this book profiles 18 chemists and discusses simple accommodations.

DISABILITY LAWS AND SERVICES

ADA Disability and Business Technical Assistance Centers

https://disabilityinfo.org/fact-sheet-library/legal/ada-disability-and-business-technical-assistance-center/ (accessed 2023-07-21)

The ADA National Network provides information, guidance and training on how to implement the Americans with Disabilities Act (ADA) in order to support the mission of the ADA to “assure equality of opportunity, full participation, independent living, and economic self-sufficiency for individuals with disabilities.” A group of 10 regional centers provide information and referral, technical assistance, training, and public awareness on ADA and related legislation.

Department of Transportation, Equal Access to Transportation
https://www.transportation.gov/accessibility (accessed 2023-07-21)

Department of Transportation, Federal Transit Administration
https://www.transit.dot.gov/regulations-and-guidance/civil-rights-ada/part-3 7-transportation-services-individuals-disabilities (accessed 2023-07-21)

Department of Transportation, Air Carrier Access Act
https://www.transportation.gov/airconsumer/passengers-disabilities (accessed 2023-07-21)

Department of Transportation, New Horizons: Information for the Air Traveler with a Disability

https://www.transportation.gov/airconsumer/new-horizons-information-air-traveler-disability (accessed 2023-07-21)

Disability Rights Section, Civil Rights Division

https://www.justice.gov/crt/disability-rights-section (accessed 2023-07-21)

The mission of this organization is to advance the nation's goal of equal opportunity, integration, full participation, inclusion, independent living, and economic self-sufficiency for people with disabilities through enforcement, regulation, and technical assistance. The Disability Rights Section works to achieve equal opportunity for people with disabilities in the United States by implementing the Americans with Disabilities Act (ADA), Section 504 of the Rehabilitation Act, and Executive Order 12250.

Equal Employment Opportunity Commission

www.eeoc.gov (accessed 2023-07-21)

EEOC develops regulations, provides training, and enforces the employment section of he ADA. Materials are available in a variety of formats. Guidance documents are published on this website, for example, Notice number 915.002 (10/10/95) Enforcement Guidance: Pre-employment Disability-Related Questions and Medical Examinations.

Federal Communications Commission

http://www.fcc.gov/encyclopedia/telecommunications-relay-services-trs (accessed 2023-07-21)

Information about Telecommunications Relay Services, including news about rulings and a consumer’s guide, can be found here.

GSA Government-wide IT Accessibility Program

www.section508.gov/ (accessed 2023-07-21)

The center provides information on Section 508 of the Rehabilitation Act of 1973, which establishes requirements for electronic and information technology developed, maintained, procured, or used by the federal government.

Job Accommodation Network

janweb.icdi.wvu.edu (accessed 2023-07-21)

The Job Accommodation Network (JAN) is the leading source of free, expert, and confidential guidance on job accommodations and disability employment issues. Serving customers across the United States and around the world for more than 35 years, JAN provides free one-on-one practical guidance and technical assistance on job accommodation solutions, Title I of the Americans with Disabilities Act (ADA) and related legislation, and self-employment and entrepreneurship options for people with disabilities.

National Education Association

https://www.nea.org/student-success/smart-just-policies/special-education (accessed 2023-07-21)

This page has information regarding IDEA and the current state of funding. NEA advocates for the fulfillment of a federal funding promise to ensure children with disabilities can access a free, quality education.

Office for Civil Rights

http://www2.ed.gov/about/offices/list/ocr/index.html?src=mr (accessed 2023-07-21)

OCR enforces federal statutes that prohibit discrimination in educational programs and activities: Section 504 of the Rehabilitation Act of 1973 and Title II of the ADA of 1990. The office also enforces laws against discrimination on the basis of race, color, and national origin (Title VI of the Civil Rights Act of 1964), sex discrimination (Title IX of the Education Amendments of 1972), and age discrimination (Age Discrimination Act of 1975).

Office of Special Education Programs

http://www2.ed.gov/about/offices/list/osers/osep/index.html?src=mr http://idea.ed.gov/ (accessed 2023-07-21)

This office has primary responsibility for administering IDEA and other programs and projects related to free public education for persons with disabilities from childhood through age 21. The office publishes an annual report to Congress on the implementation of IDEA and the Guide to the Individualized Education Program for educators, parents, and educational agencies.

Parent Advocacy Coalition for Educational Rights

www.pacer.org (accessed 2023-07-21)

Founded in 1977, the PACER Center was created by parents of children and youth with disabilities to help other parents and families facing similar challenges. The website includes links to parent training and information centers and community groups in the United States.

National Center on Secondary Education and Transition

http://www.ncset.org (accessed 2023-07-21)

The National Center on Secondary Education and Transition (NCSET) was originally funded by the U.S. Department of Education's Office of Special Education Programs from 2000 to 2008, during which time it partnered with six major organizations also focused on the secondary education and transition of youth with disabilities. NCSET coordinated national resources, offered technical assistance, and disseminated information related to secondary education and transition for youth with disabilities in order to create opportunities for youth to achieve successful futures. Although NCSET is no longer funded through OSEP, they continue to disseminate resources via the website with support from the Institute on Community Integration in the University of Minnesota's College of Education and Human Development.

Technical Assistance Program

www.usdoj.gov/crt/ada/taprog.htm (accessed 2023-07-21)

The Department provides education and technical assistance through a variety of means to encourage voluntary compliance. Activities include providing direct technical assistance and guidance to the public through this ADA website and the ADA Information Line, developing and disseminating technical assistance materials to the public, and undertaking outreach initiatives.

United States Access Board

www.access-board.gov (accessed 2023-07-21)

This federal agency was created under the Rehabilitation Act of 1973, as amended, with the primary mission of ensuring accessibility for people with disabilities under the Architectural Barriers Act of 1968, the ADA of 1990, and the Telecommunications Act of 1996. The agency offers training and technical assistance to individuals and organizations throughout the country on removing architectural, transportation, and communication barriers.

US. Department of Justice: ADA Information Line

1-800-514-0301

TTY 800-5141-0383

U.S. Department of Justice Guide to Disability Rights Laws

https://www.ada.gov/cguide.htm#anchor62335 (accessed 2023-07-21)

This guide provides an overview of Federal civil rights laws that ensure equal opportunity for people with disabilities. To find out more about how these laws may apply to you, the site lists agencies and organizations that can be contacted.

GENERAL CONSIDERATIONS AND UNIVERSAL DESIGN

American Chemical Society

https://www.acs.org/content/acs/en/about/diversity.html?sc=210101_print_ad_cen_deir_filler (accessed 2023-07-21)

The American Chemical Society site for Diversity, Equity, Inclusion, and Respect provides multiple resources to create an inclusive culture in a variety of contexts.

American Chemical Society Exams Institute

https://uwm.edu/acs-exams/accessibility-statement/ (accessed 2023-07-21)

The American Chemical Society Exams Institute fully supports fair testing of all students. This site shares information for providing accommodations and/or accessible exams.

American Institute of Architects

https://aia.org (accessed 2023-07-21)

AIA makes referrals to architects who can design living and work environments for persons with disabilities.

Association of Higher Education Facilities Officers

www.appa.org (accessed 2023-07-21)

APPA offers a wealth of informational resources, continuous learning programs, and opportunities to connect and network with fellow facilities professionals in a welcoming and inclusive environment.

Bookshare

www.bookshare.org (accessed 2023-07-21)

Bookshare makes reading easier. People with dyslexia, blindness, cerebral palsy, and other reading barriers can customize their experience to suit their learning style and find virtually any book they need for school, work, or the joy of reading.

Center for Applied Special Technology

www.cast.org (accessed 2023-07-21)

CAST provides research and support for "Universal Design for Learning," a system that uses technology to make curricula more accessible to all students, including those with disabilities.

Center for Inclusive Design and Innovation (CIDI)

https://cidi.gatech.edu/ (accessed 2023-07-21)

CIDI is recognized as a leader for services and research in accessibility. They are dedicated to an inclusive society through innovations in assistive and universally designed technologies, with a goal of addressing the full range of needs for accessibility. They are committed to the promotion of technological innovation and development of user-centered research, products, and services for individuals with disabilities.

DO-IT (Disabilities, Opportunities, Internetworking, and Technology)

www.uw.edu/doit/ (accessed 2023-07-21)

The University of Washington helps to advance the success of people with disabilities in education, research, and careers. This site provides extensive resources for teaching science and related subjects to students with disabilities.

IDeA Center

http://universaldesign.com/ (accessed 2023-07-21)

In 2015, John Salmen, founder and President of Universal Designers & Consultants, Inc., entrusted the future of UniversalDesign.com to the IDeA Center. The IDeA Center is internationally known as a center of excellence in the field of universal design (UD). Founded in 1984, the IDeA Center is dedicated to improving the design of environments and products by making them more usable, safe, and appealing to people with a wide range of abilities, throughout their life spans.

Learning Ally

http://www.learningally.org/ (accessed 2023-07-21)

Learning Ally hosts a College Success Program (CSP) which offers a robust set of resources—articles, videos, audio recordings, webinars, etc.—that cover a wide variety of topics. Everything from career exploration to learning effectively, from living on your own to making connections, from partnering with your disability services office to discovering technology. Almost any situation you encounter or question you may have is covered in these resources.

National Library Service for the Blind and Physically Handicapped

www.loc.gov/nls (accessed 2023-07-21)

NLS administers a free library program of Braille and recorded materials to people who are unable to use standard print materials. A network of cooperating libraries circulates materials to borrowers by postage-free mail. To find the library in your state, go to www.loc.gov/nls/find.html or contact the NLS or your local public library.

Patton Educational Products Co.

www.pepcosciencetables.com (accessed 2023-07-21)

PEPCO makes a durable science laboratory table with enough clearance underneath to be accessible for most wheelchairs.

Synapse Adaptive

www.synapseadaptive.com (accessed 2023-07-21)

SA is a commercial source of access and productivity tools, including speech recognition, augmentative communication, and learning tools, vision products, ergonomic furniture and apparatus, and information.

WGBH Media Access Group, WGBH Educational Foundation

http://main.wgbh.org/wgbh/pages/mag/ (accessed 2023-07-21)

Boston-based public broadcaster WGBH formed the Media Access Group to serve people who are deaf, hard-of-hearing, blind, or visually impaired. The new unit consolidates WGBH's two nonprofit access service departments: The Caption Center, the world's first captioning agency, founded in 1972 to make television, film, and video accessible to deaf and hard-of-hearing viewers, and Descriptive Video Service (DVS), which has made these forms of media more accessible to blind and visually impaired audiences since 1990. DVS also has a research and development entity, the CPB/WGBH National Center for

Accessible Media, which is devoted to increasing access to existing and emerging technologies.

TECHNOLOGY

Apple Computer, Inc.

http://www.apple.com/education/special-education/ (accessed 2023-07-21)

http://www.apple.com/accessibility/ (accessed 2023-07-21)

Apple provides comprehensive information about its computer products and peripherals for people with disabilities.

Captek

http://www.captek.net (accessed 2023-07-21)

Products such as calculators, meters with talking output for visually impaired persons, and a variety of magnifiers are available. Staff have extensive experience in the fields of digital voice technology and equipment adaptation. Call to order a catalog or to discuss adaptation needs.

Closing the Gap

www.closingthegap.com (accessed 2023-07-21)

Closing the Gap disseminates the latest developments in software, hardware, and adaptive technology for persons with disabilities. They host training opportunities and an annual conference.

Duxbury Systems, Inc.

www.duxburysystems.com (accessed 2023-07-21)

Duxbury leads the world in software for braille. The Duxbury Braille Translator (DBT) is used by virtually all of the worlds' leading braille publishers and supports many languages.

EMAC SPEAK

emacspeak.sourceforge.net (accessed 2023-07-21)

This free speech interface allows blind and visually impaired users to interact with a computer, especially for web and Internet use. Also compatible with Linux and IBM ViaVoice Outloud, it is available on the Internet.

Equal Access to Software Information (EASI)

http://easi.cc/ (accessed 2023-07-21)

EASI provides extensive information on electronic accommodations for students with disabilities at all levels of education, from kindergarten through college. Although the emphasis is on adaptive computer technology and accessible information technologies, this is a very extensive website with links to information and resource materials on many topics related to science education for students at all levels.

Freedom Scientific

www.freedomscientific.com (accessed 2023-07-21)

Freedom Scientific emerged as the largest U.S. manufacturer of software and hardware for people with vision impairments when it was formed by the merger of Blaize Engineering, Henter-Joyce, and Arkenstone [later Learning Systems Group] in early 2000. Products include the JAWS screen reading software and magnification software such as ZoomText.

IBM Accessibility Center

http://www-03.ibm.com/able/ (accessed 2023-07-21)

The center provides free information and guides on the use of personal computers, as well as a series of IBM products for persons with disabilities in the following areas: vision, speech/hearing, mobility, education, and cognitive/dyslexia.

LS&S Group, Inc.

http://www.lssproducts.com/ (accessed 2023-07-21)

This company publishes a catalog of instruments and devices for those with disabilities. They carry a selection of keyboard options and several software choices for screen reading and enlargement or voice input. There are also signaling systems that can attach flashing lights or vibrating devices to electronic equipment.

Microsoft's Accessibility Features

www.microsoft.com/enable (accessed 2023-07-21)

Accessibility features built into Microsoft products such as Windows and Microsoft Office are described, as well as a list of accessible computing centers.

National Center on Accessible Information Technology in Education (AccessIT)

www.washington.edu/accessit (accessed 2023-07-21)

The center provides resources to help educational entities purchase, develop, and use information technology that is welcoming to, accessible to, and usable by everyone, including people with disabilities. They provide support for web design and accessible technology.

Nuance

http://www.nuance.com/ (accessed 2023-07-21)

Dragon is a widely used speech recognition software for computer use. Products include Dragon Anywhere for mobile use.

Prentke Romich Co.

http://www.prentrom.com/ (accessed 2023-07-21)

The company, which specializes in augmentative communication (speech output) devices, offers computer access products and other assistive technology. In addition, it reportedly makes software that allows the use of chemical drawing software (such as ChemDraw) via voice access, without the need for hands on the keyboard.

Rehabilitation Engineering & Assistive Technology Society of North America

www.resna.org (accessed 2023-07-21)

RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America, is the premier professional organization dedicated to promoting the health and well-being of people with disabilities through increasing access to technology solutions. RESNA advances the field by offering certification, continuing education, and professional development; developing assistive technology standards; promoting research and public policy; and sponsoring forums for the exchange of information and ideas to meet the needs of their multidisciplinary constituency.

Telesensory

www.telesensory.org (accessed 2023-07-21)

Telesensory manufactures video magnifiers (CCTVs), scanners (OCR), and screen magnification products for people who are blind or vision-impaired.

Trace Research and Development Center

https://trace.umd.edu/ (accessed 2023-07-21)

Trace's mission is to capitalize on the potential that technologies hold for people experiencing barriers due to disability, aging, or digital literacy, and to prevent emerging technologies from creating new barriers for these individuals.

UN-SCAN-IT and UN-SCAN-IT gel

http://www.silkscientific.com/ (accessed 2023-07-21)

UN-SCAN-IT and UN-SCAN-IT gel digitize graphs and gels, respectively. The software, available for both Windows and Macintosh platforms, produces data in ASCII format for export to other programs.

TRANSITIONING TO HIGHER EDUCATION AND CAREERS

American Chemical Society (ACS) Career Services

https://www.acs.org/careers (accessed 2023-07-21)

ACS Career Services enhances the economic and professional status of chemistry professionals. Services and products provide direct contact with employers, career assistance, and information on employment data, trends, and issues.

DO-IT

www.washington.edu/doit (accessed 2023-07-21)

The University of Washington helps to advance the success of people with disabilities in education, research, and careers. This site provides extensive resources for teaching science and related subjects to students with disabilities. They also have volunteer mentors, ambassadors, and others who share their experiences and insight to support and encourage students with disabilities pursuing college and careers.

Entry Point!

www.entrypoint.org (accessed 2023-07-21)

AAAS manages Entry Point!, a program to recruit and counsel undergraduate and graduate students with disabilities majoring in science or engineering and place them in paid summer internships with NASA, NSF, IBM, and other technical companies in the private sector.

K. Lisa Yang and Hock E. Tan Institute on Employment and Disability at Cornell University

https://www.yti.cornell.edu/ (accessed 2023-07-21)

Housed in Cornell University's School of Industrial and Labor Relations, the *K. Lisa Yang and Hock E. Tan* Institute on Employment and Disability conducts research and provides continuing education and technical assistance on many aspects of disability in the workplace.

National Institutes of Health

www.nih.gov (accessed 2023-07-21)

NIH offers predoctoral fellowships for students with disabilities and research supplements for students with disabilities from high school through the postdoctoral level. The NIH research supplements for individuals with disabilities are described at http://grants.nih.gov/grants/guide/pa-files/PA-05-015.html or via a search for PA number PA 05-015. NIH also funds research of benefit to persons with disabilities, which is described at www.nih.gov.

National Science Foundation

www.nsf.gov (accessed 2023-07-21)

Office of Disability Employment Policy (ODEP)

https://www.dol.gov/agencies/odep (accessed 2023-07-21)

In the FY 2001 budget, Congress approved a new ODEP for the Department of Labor. Programs and staff of the former President's Committee on Employment of People with Disabilities have been integrated into this new office. ODEP's mission is to develop and influence policies and practices that increase the number and quality of employment opportunities for people with disabilities. ODEP promotes the adoption and implementation of ODEP policy strategies and effective practices — meaning those that ODEP has developed and/or validated — that will impact the employment of people with disabilities.

Vision Impairment

American Foundation for the Blind

www.afb.org (accessed 2023-07-21)

Since 1921, AFB has been a leader in expanding possibilities for the nearly 25 million Americans living with vision loss. A national nonprofit, they champion access and equality, and stand at the forefront of new technologies and evidence-based advocacy. They address the most pressing needs of people with vision loss and their families, breaking down societal barriers and promoting broad systemic change.

American Printing House for the Blind, Inc.

www.aph.org (accessed 2023-07-21)

This organization offers textbooks for students in grades K-–12 in Braille and enlarged print, preschool packets, and other educational products.

National Braille Association

www.nationalbraille.org/ (accessed 2023-07-21)

NBA serves as a clearinghouse for the exchange of ideas and suggestions for the improvement of Braille transcribing techniques. NBA publishes guidelines for standards of print to Braille formats; offers continuing education seminars; and conducts workshops for Braille transcribers, tactile illustrators, production workers, and others who prepare reading matter for the visually impaired. The association maintains the Braille Book Bank of college-level textbooks, technical materials, music, and items of a more general nature. The Braille Technical Tables Bank is a collection of standard tables used in math, computer science, statistics, chemistry, physics, and finance.

National Federation of the Blind

www.nfb.org (accessed 2023-07-21)

This nation's largest self-help organization for blind Americans offers scientists who lose their sight free consultation and networking for any problem related to blindness through its professional Science and Engineering Division and educational materials (web page, print, alternative formats). Data are available on procedures for laboratories; researching and writing; locating or transcribing texts; adaptive equipment for scientific specialties; management techniques for office, classroom, or professional conferences; and assistance in job searching through its JOB program.

Sensory Access Foundation

www.sensoryaccess.org (accessed 2023-07-21)

SAF assists individuals who are blind or visually impaired in obtaining suitable employment or maintaining an existing job that is at risk because of visual problems affecting an employee's ability to do the job. SAF provides workplace accommodations (specialized hardware and software) that allow employees to do their jobs. SAF's employment services include job preparation and placement, access technology evaluations, employer/employee education, ADA consultation, equipment loan for on the job, individualized access technology training, installation and configuration of systems, and the work incentive program.

DEAF AND HARD OF HEARING

Alexander Graham Bell Association for the Deaf and Hard of Hearing

www.agbell.org (accessed 2023-07-21)

Started in 1890 by Alexander Graham Bell, this is a membership organization and source of information on hearing loss and the auditory approach. The foundation also offers financial aid to qualified students.

Gallaudet University

www.gallaudet.edu (accessed 2023-07-21)

Gallaudet University serves as a comprehensive, multipurpose institution of higher education for citizens of the United States and of the world who are deaf or hard-of-hearing. In addition to its undergraduate and graduate academic programs, the university also offers national demonstration elementary and secondary education programs.

National Technical Institute for the Deaf

http://www.ntid.rit.edu/ (accessed 2023-07-21)

NTID, one of seven RIT colleges, is the world's first and largest technological college for deaf students. NTID represents the first concentrated effort to educate large numbers of deaf students within a college campus planned principally for hearing students. Students can benefit from nearly 200 technical and professional courses of study offered by NTID and RIT's colleges of Applied Science and Technology, Business, Engineering, Imaging Arts and Sciences, Liberal Arts, and Science.

Registry of Interpreters for the Deaf, Inc.

www.rid.org (accessed 2023-07-21)

The Registry promotes professional, qualified, and competent interpreters for both deaf and hearing consumers by administering the National Testing System and can provide a list of interpreting agencies by state. The website contains a searchable database for finding local interpreters.

Sign Language Associates, Inc.

www.signlanguage.com (accessed 2023-07-21)

This organization is one of many in the Washington, D.C. area that provides interpreters for meetings and other functions. Many of them (including Sign Language Associates) make arrangements for interpreters in other parts of the country as well.

Technology Access Program

http://tap.gallaudet.edu/ (accessed 2023-07-21)

Gallaudet University's Technology Access Program (TAP) is a research group focusing on technologies and services that eliminate communication barriers traditionally faced by deaf and hard-of-hearing people. TAP currently receives primary support from the National Institute on Disability and Rehabilitation Research and Gallaudet University's Department of Communication Arts.

SPEECH IMPAIRMENT

Prentke Romich Co.

https://www.prentrom.com/ (accessed 2023-07-21)

A leader in the development of speech-generating devices and innovator in the field of augmentative and alternative communication.

MOBILITY IMPAIRMENT

United Cerebral Palsy

www.ucp.org (accessed 2023-07-21)

UCP is one of the major disability-related charities in America, promoting full inclusion of people with disabilities in every aspect of life. UCP also provides direct services to people with disabilities and their families through local affiliates.

United Spinal Association

www.unitedspinal.org (accessed 2023-07-21)

United Spinal Association is a national 501(c) (3) nonprofit membership organization dedicated to empowering people with spinal cord injuries and disorders (SCI/D), including veterans, to live successful and fulfilling lives.

LEARNING DISABILITIES

Children and Adults with Attention Deficit/Hyperactivity Disorders

www.chadd.org (accessed 2023-07-21)

Founded in 1987 by a group of concerned parents, CHADD works to improve the lives of people with attention deficit/hyperactivity disorder through education, advocacy, and support. Working closely with leaders in the field of AD/HD research, diagnosis and treatment, CHADD offers its members and the public information they can trust.

International Dyslexia Association

www.interdys.org (accessed 2023-07-21)

The society is committed to sharing up-to-date information about workplace accommodations and advances in the field of dyslexia through an extensive list of reprints and other readings, including college and career selections.

Landmark College

www.landmark.edu/ (accessed 2023-07-21)

Landmark College is one of the only accredited colleges in the United desig
exclusively for students who learn differently, including students with disabilities (such as dyslexia), attention deficit hyperactivity disorder and autism. Landmark College's mission is to transform the way students learn, educators teach, and the public thinks about education. We provide highly approaches to learning that empower individuals who learn differently to exceed aspirations and to achieve their greatest potential.

Learning Disabilities Online

www.ldonline.org (accessed 2023-07-21)

This website for families and teachers of students with disabilities contains numerous links to resources. It is also the official internet source for publications of the National Joint Committee on Learning Disabilities.

National Center for Learning Disabilities

www.ncld.org (accessed 2023-07-21)

As a member organization of the National Joint Committee on Learning Disabilities, NCLD is devoted to increasing opportunities for all individuals with learning disabilities to achieve their potential. NCLD accomplishes this mission by increasing public awareness and understanding of learning disabilities, conducting educational programs and services that promote research-based knowledge, and providing national leadership in shaping public policy.

National Joint Committee on Learning Disabilities

www.ldonline.org/njcld (accessed 2023-07-21)

This group, composed of representatives from 10 member organizations, provides interdisciplinary review of topics related to learning disabilities and releases consensus statements to clarify these issues. Member organizations include the American Speech-Language-Hearing-Association, the Association for Higher Education and Disability, the Council for Learning Disabilities, the Division for Children's Communication Development, the Division for Learning, Disabilities Council for Exceptional Children, the International Dyslexia Association, the Learning Disabilities Association of America, the National Association of School Psychologists, and the National Center for Learning Disabilities.

Schwab Foundation for Learning

www.SchwabLearning.org (accessed 2023-07-21)

This website offers more than 200 pages of content on learning differences and disabilities. Publications and fact sheets for families of students with learning disabilities can be downloaded.

TRAVEL

DisabledTravelers.com

http://www.disabledtravelers.com/ (accessed 2023-07-21)

This site is a resource dedicated to accessible travel information and provides information on businesses from around the world that specialize in disability travel.

DOT Air Carrier Access Hotline (accessed 2023-07-21)

https://www.transportation.gov/airconsumer/toll-free-hotline-air-travelers-disabilities

The hotline will provide general information to consumers about the rights of air travelers with disabilities, respond to requests for printed consumer information, and assist air travelers with time-sensitive disability-related issues that need to be addressed in "real time."

Mobility International USA

www.miusa.org (accessed 2023-07-21)

An important part of MIUSA's mission is to ensure the inclusion of people with disabilities in international educational exchange programs. MIUSA manages the National Clearinghouse on Disability and Exchange. NCDE promotes the inclusion of people with disabilities in educational exchange programs and provides technical information to colleges, universities, and international exchange organizations on how to include people with disabilities in exchange programs. Many publications and videos are available from MIUSA, including *A World Awaits You* (*AWAY*), a journal of success in international exchange for people with disabilities.

Society for Accessible Travel and Hospitality

www.sath.org (accessed 2023-07-21)

Information for persons with disabilities traveling in the United States or internationally is available, along with Open World magazine.

Transportation Security Administration Travelers with Disabilities and Medical Conditions

https://www.tsa.gov/travel/special-procedures (accessed 2023-07-21)

This site provides information and requirements for safe travel.

Credits: Meet the Authors

Stephanie A. Hall, **MS MA**, has taught Science and Special Education in the secondary setting for 15 years where she helps students and teachers find ways to overcome challenges presented by disabilities. Stephanie received an MS in Integrated Science Education from Montana State University and an MA in Special Education in Special Education from the University of Wyoming. Stephanie also completed BS degrees in Equine Science (Pre Vet) from Colorado State University and Range Ecology and Watershed Management from the University of Wyoming. Stephanie has multiple disabilities so understands the needs of students with disabilities from both the student and the teacher side of the equation. Pictured with current service dog “Hun E. Bun”.

Carl E. Heltzel, Ph.D., is an Associate Professor at the Medical University of South Carolina and the Hollings Cancer Center Grants Development Director and Senior Science Writer. Over the previous 10 years, he was a freelance professional grant writer and science writer (Heltzel Editorial, LLC). A member of the ACS for more than 30 years, he served on three ACS national committees, the most recent being the *Committee on Chemists with Disabilities.* He co-authored the fifth and sixth editions of the ACS textbook, *Chemistry in Context* and is a past editor of the ACS magazine, *ChemMatters*. He also has been teaching an online ACS chemistry course since 2010. Heltzel served as co-editor and chapter author for the ACS book, *Accessibility in the Laboratory*. He has earned national and international awards for technical writing, editing, and teaching. His first independent academic position was at Transylvania University where he started in 1997 as Assistant Professor, was awarded tenure and promoted in 2002 to Associate Professor, and a year later was named the Monroe Moosnick Professor of Chemistry. Additional teaching included positions at Clemson University, University of Hawaii, University of Kentucky, and Chaminade University. He earned a Ph.D. in organic chemistry, VA Tech (1989–1993) and enjoyed an NSF postdoctoral fellowship at the University of Hawaii, Manoa (1993–1995).

Kevin L. Kelly, Ph.D., is a Research Chemist with the Bureau of Reclamation, U.S. Department of the Interior. He obtained his BS in chemistry from Willamette University and his Ph.D. in environmental chemistry from the University of Colorado, Boulder. He leads various multi-disciplinary research teams focusing on the impacts of the environment on the operations and maintenance of Reclamation's water delivery infrastructure. He also performs underwater inspections of Reclamation dams in the western 17 states and recruits deaf college students into internships and permanent positions with Reclamation. Dr. Kelly is a long-time member of ACS and currently serves as a member of the Chemists with Disability committee. kkelly@usbr.gov, www.usbr.gov.

Mona Minkara, Ph.D. is a blind Assistant Professor in the Department of Bioengineering and an Affiliate Faculty in the Department of Chemistry and Chemical Biology at Northeastern University where she leads the COMBINE Lab. Dr. Minkara's research at Northeastern focuses on using computational methods to study biological interfaces at the atomic and molecular scale. Currently, her research group uses molecular dynamics simulations, molecular docking calculations, homology modeling, and Monte Carlo simulations to investigate pulmonary surfactant, the complex protein-lipid substance that lines the alveoli in the lungs. More information about Dr. Minkara is available on her personal website www.monaminkara.com.

Ashley Neybert is a blind chemist and curriculum designer. She received her BS in Chemistry from Rockhurst University in Kansas City, Missouri in 2015 with thesis work done with Dr. Jack Barbera and is currently in her last semester of her Masters in Education at Wichita State University with thesis work on sonification usage in general chemistry classrooms. She works for Independence Science, a consulting agency with a mission of serving blind and low vision scientists and those who support them. Her favorite part of her job is working with instructors to make their teaching more accessible. She enjoys volunteering her time working with the ACS Chemists with Disabilities Committee and serving as Vice-President of the National Federation of the Blind Scientists and Engineers Division.

Amie Norton, Ph.D. is a member of the ACS Committee on Chemists with Disabilities. She received her Ph.D. from the University of Cincinnati in chemistry in 2017. She currently works in the Department of Entomology at Kansas State University on nanotechnology in crop pests. When not working, she spends her time with family, friends, and her dogs Max and Champo.

Todd Pagano, Ph.D. is a Professor of Chemistry and Associate Dean for Teaching and Scholarship Excellence at Rochester Institute of Technology/National Technical Institute for the Deaf (RIT/NTID). He conducts research in analytical/physical chemistry and science pedagogy and is active in involving students in undergraduate research projects in the chemical sciences. He has been honored as a recipient of RIT's Richard & Virginia Eisenhart Award for Excellence in Teaching, Albritton Faculty Humanitarian Award, and Faculty Mentoring Award as well as the CASE/Carnegie U.S. Professor of the Year Award. He was also recognized with the American Chemical Society's (ACS) Stanley C. Israel Award for Advancing Diversity in the Chemical Sciences and the National Award for Encouraging Disadvantaged Students into the Chemical Sciences. Dr. Pagano is a long-time member of the ACS and has served on both the Committee on Chemists with Disabilities and International Activities Committee. He is a Fellow of both the ACS and the Royal Society of Chemistry. He has consulted for the National Academy of Science, served as a Fulbright Specialist, and is editor of the *Journal of Science Education for Students with Disabilities*.

Kathleen Palatucci, MA, CCC-SLP, is the current President of the New Jersey Speech-Language-Hearing Association (NJSHA) and recently retired from Montclair State University where she served as the Speech-Language Pathology (SLP) Clinic Director and Externship Coordinator. She has 23 years of experience as an SLP across educational and medical settings. She has served 15 years as an externship student supervisor. In addition to her current Executive Board position, Kathleen has been active in NJSHA as Healthcare Committee Chair and Vice-Chair and as a member of the Board of Directors. Kathleen served 5 years as the New Jersey representative to the American Speech-Language Hearing Association (ASHA) Advisory Council as the NJ-SLP. Kathleen continues in her role as a mentor to clinicians entering the field and is a strong advocate for collaborative practices across settings and disciplines. kathy4njsha@gmail.com.

Melissa Postlewaite has a multidisciplinary science background. She served as a member of the ACS Chemists With Disabilities Committee for 10 years. She helped pilot a disability committee at the American Institute of Chemical Engineers called the Disability Outreach and Inclusion Community where she is currently serving as chair. MelissaPostlewaite@gmail.com.

Patricia Ann Redden, Ph.D., is Professor Emerita of Chemistry at Saint Peter's University in Jersey City, NJ, where she taught for 53 years before retiring in 2021. She served for 32 years as the department chair and taught a variety of courses for chemistry and non-science majors as well as Methods of Teaching Science in the Elementary School. She has been a Counselor for the New York Section of the American Chemical Society (ACS) for over 35 years, most recently serving on the Committee on Chemists with Disabilities since 2015 and as liaison since 2017 to the Committee on Chemical Safety, on

which she served for a total of 30 years. She is a Fellow of the American Chemical Society and of the Division of Chemical Health and Safety. As the mother of two daughters who are polio survivors, she has been active in the disabled community for the last 35 years. She is a USA Track and Field official, certified at the National and Paralympic levels, regularly officiating at adaptive meets. She is also a puppy raiser for Canine Companions, a national organization that provides trained service dogs at no cost to individuals with disabilities, and is currently raising her tenth puppy for that organization.

Annemarie Ross, Ph.D. is an Associate Professor and coordinator of the Laboratory Science Technology program at the Rochester Institute of Technology/National Technical Institute for the Deaf (RIT/NTID). She has been awarded the American Chemical Society's (ACS) Stanley C. Israel Award for Advancing Diversity in the Chemical Sciences and the NTID Award for Teaching for pre-tenured faculty. She does research in the fields of Chemistry and Deaf Education. She has been a member of the ACS Committees on Chemists with Disabilities and Technician Affairs and the Macmillan Learning's Accessibility Advisory Board. She has developed curriculum for a number of courses/programs and works to develop/standardize American Sign Language signs for STEM fields to be used with Deaf, STEM professionals/students and their interpreters.

Thomastine A. Sarchet-Maher, Ed.D. is an associate research professor and assistant dean at the National Technical Institute for the Deaf, at the Rochester Institute of Technology. Dr. Sarchet-Maher's work in Deaf education spans nearly 20 years. She is a trained secondary science teacher, specializing in biology and biotechnology and currently works as a teacher educator and trainer for Deaf education programs in the U.S. and abroad. Her current research with Deaf learners focuses academic achievement in STEM, metacognition, and social-emotional development in the transition between high school and college. Dr. Sarchet-Maher also serves as the director for the Center for International Educational Outreach. In this role, Dr. Sarchet-Maher oversees teacher and interpreter Deaf Education projects in Southeast Asia and Africa.

Theresa Windus, Ph.D., is a Distinguished Professor and Liberal Arts and Sciences Dean's Professor in the Department of Chemistry at Iowa State University, a scientist at the Department of Energy's Ames National Laboratory (AL), and a member of the Critical Materials Institute led by AL. She is also a Co-Director and Deputy Director for the Molecular Sciences Software Institute (MolSSI), and the Director for the DOE NWChemEx Exascale Computing Project. Previously, Dr. Windus was a Senior Scientist and Technical Group Lead at Pacific Northwest National Laboratory (PNNL) where she led a multidisciplinary team focusing on enabling computational resources for users at PNNL. She was also the technical group lead for the Molecular Sciences Software Group and led the development of NWChem—a leading

worldwide software. Dr. Windus' current research interests are rare earth and heavy element chemistry, catalysis, aerosol formation, cellulose degradation, and design and development of efficient and novel massively parallel chemistry algorithms. She is an elected Councilor for the PHYS division of the American Chemical Society (ACS), serves on the Chemists with Disabilities Committee (ACS), is a Fellow of the ACS and of the American Association for the Advancement of Science, and has won multiple awards for her teaching and research. https://www.chem.iastate.edu/people/theresa-windus.

Hoby Wedler, Ph.D., is a blind scientist, sensory expert, and entrepreneur. In 2011, Dr. Wedler founded Accessible Science, a nonprofit organization that leads annual chemistry camps for blind or visually impaired students throughout North America. That same year, he began opening doors to the world of wine aromas by holding blindfolded wine tastings in Francis Ford Coppola's wineries. In 2012, he was named a Champion of Change by President Barack Obama for enhancing employment and education opportunities for people with disabilities. In 2016, he earned his doctorate from the University of California–Davis in organic chemistry and was named one of Forbes Media's 30 under 30. In 2017, he co-founded Senspoint, a global creative and strategic consultancy committed to helping those whose work to make the world more accessible and sustainable. Dr. Wedler also serves as a motivational speaker, mentor, and educator, and his initiatives have touched those whose journeys he successfully guided to new levels of awareness and success. More information about Dr. Wedler is available on his personal website: https://www.hobywedler.com.

Sarah R. Zinn, Ph.D., is a Postdoctoral Fellow with a joint appointment in the Department of Chemistry and the Center for Laboratory Safety at the University of California, Los Angeles (UCLA). After receiving a joint BS first of her class in chemistry and applied physics from Ohio Northern University, Dr. Zinn completed her doctoral work at the University of Chicago as an NDSEG Fellow and received a certification from the University of Chicago Center for College Teaching. During her doctoral work, Dr. Zinn used ultrafast two-dimensional electronic spectroscopy to investigate the key design principles of photon-harvesting synthetic macromolecular organic systems. While a doctoral candidate in chemistry, however, Dr. Zinn became intensely interested in the culture of academic research institutions and began taking classes and conducting research in the Division of Social Sciences at the University of Chicago in her spare time. Now, Dr. Zinn studies the institutional structures and traditions that influence the behavior of students and researchers in the chemical sciences. Dr. Zinn has been chronically ill, disabled, and undiagnosed in academia since middle school, only recently receiving official diagnoses of a cluster of rare conditions.

DISCLAIMER

The information and resources contained in *Teaching Chemistry to Students with Disabilities* have been compiled from what are believed to be reliable sources and are intended to promote and support the full and reasonable participation of those with disabilities as they pursue education particularly in the chemical sciences. The American Chemical Society (ACS) does not, however, purport in these materials and resources to specify the minimum safety or legal standards or to address all of the compliance requirements or safety procedures associated with providing accommodations related to people with disabilities. This information is intended to serve only as a starting point for accepted practices and should not be construed as containing all the necessary compliance, safety, or warning information, nor should it be construed as representing the policy of ACS.

No warranty, guarantee, or representation is made by ACS as to the accuracy or completeness of the information contained in these materials and resources, and ACS assumes no liability or responsibility in connection therewith. The users of the materials and resources are responsible for complying with all pertinent local, state, and federal laws, regulations, and standards, and they should consult with legal counsel or other professional advisers about applicable laws, safety issues, and compliance issues.

The use of brand names and/or names of manufacturers is informational only and does not imply endorsement of any product or service referenced therein.