A GUIDE TO THE SCIENCES AT TJHSST

Opportunities for the motivated student

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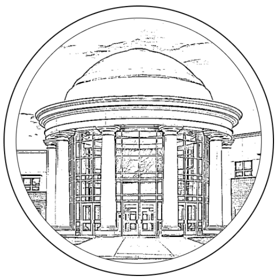

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1

INTRODUCTION

We are a current group of seniors at Thomas Jefferson High School (Class of 2018). Given our experiences over the past four years, and our naive view of high school just a few short years ago, we wish to highlight some misconceptions and provide tips to those who may come after us.

This is a terse guide to the sciences at Thomas Jefferson High School. It is designed for current and future TJ students with STEM interests. This guide focuses on many of the opportunities available to a TJ STEM student both inside and outside the classroom.

1.1 DISCLAIMER

Take our advice with a grain of salt. Your experiences may differ, depending on your specific interests. Facts, figures, and statistics will change over time; their accuracy is not guaranteed. This book is a reflection of our experiences, which comprise a fraction of the opportunities at TJ. We are not responsible for the choices you make based on this material, or your admission or rejection to any higher education institution.

This book is not endorsed or affiliated with TJHSST or any related organization. It has not been reviewed or edited by any member of the TJ faculty or administration.

This guide details *some* of the options available to STEM students. It is by no means a complete and thorough overview of all available opportunities. Furthermore, we encourage students to choose whatever activities they enjoy the most. To any parents who may be reading this guide: it is designed for students, and students *only*. We urge parents to let their children decide what's best for them academically, both inside and out of school. From our personal experience, little good comes from parents who force their children to participate in activities they do not truly enjoy.

1.2 OVERVIEW

The layout of the book is as follows. The next chapter is simply a list of guiding principles that you should try to follow over your high school career. Chapter 3 provides information on TJ academic opportunities, and Chapter 4 gives a summary of important STEM clubs at TJ. Chapter 5 gives advice when deciding which activities to pursue.

Chapters 6–8 are the meat of the book. They provide information on two tracks a STEM student can take through high school: Olympiad camps and research. Each of the authors has seen some success in camps or research, and each provides their insight, advice, and words of warning for your journey.

Chapters 9–12 turn towards the inevitable conclusion of your TJ career: college. Since most of your success/failure in the college admissions process will be determined by your accomplishments (hence the focus on camps and research in earlier chapters), Chapters 9–12 are fairly short explanations of the other factors (standardized exams, resume-boosting activities, applying early vs. regular, etc). You shouldn't start thinking about colleges until the end of junior year, so this information is geared towards rising seniors. These sections are not designed for younger students, as they should not be influenced by college preferences when choosing their activities.

1.3 THE SCOPE OF THIS BOOK

There are plenty of humanities opportunities at TJ. TJ boasts some of the finest fine arts programs, from nationally recognized orchestra, band, and choir programs, to the award-winning yearbook and Teknos publication. Hundreds of TJ students play instruments outside of school—from the piano and violin to the saxophone and bagpipes. Hundreds of others participate in sports, from the relaxed cross country team to the grueling schedule of basketball and football.

This guide makes no attempt to cover any of these opportunities. The authors only have experience and accomplishments in fields of science, technology, and mathematics. This book is a guide for students who enjoy the sciences, and want to take their academic interests further—into competitions, research, and projects. All of our advice centers around the basic assumption that you enjoy the sciences, and want opportunities to further your knowledge and interest in the field. As such, almost none of this book will be useful for students fully engrossed in the humanities or athletics. Even our college advice centers around our experiences and knowledge of previous STEM students. We have no knowledge of which athletic, artistic, literary, or musical accomplishments and competitions colleges historically prefer.

1.4 THE INTENDED AUDIENCE

This guide is intended for motivated students looking for additional opportunities to further their STEM knowledge. We aim to elucidate various activities available to students seeking a scientific challenge. We encourage readers to decide for themselves whether or not they fit this description. Those who find the TJ curriculum alone provides enough work should simply ignore this guide and read no further; it is not applicable to their experience at TJ. (The fact that we include a lengthy section on 'Skip Tests' should suggest our target demographic.) We advise students just entering TJ to take some time to get situated to the school and coursework and then revisit the guide if and only if they fit the above description.

This guide is not a novel; it is not intended to be read in its entirety in one sitting. Most information will only be applicable to select students at certain times. For example, the initial sections on classes will be useful to some during course selection, while the parts on research programs will be important to others as application deadlines near. The chapter on Olympiad camps is primarily aimed at freshmen/sophomores, since it is nearly impossible for juniors with no prior preparation to attend a camp. On the other hand, older students are overrepresented in research competitions, so they may find Chapter 7 more applicable.

Students interested solely in a particular STEM field may find different sections of the book useful. For example, a student focused on computer science may find the sections on skip tests (12–15), USACO camp (38–40), and independent research (61–63) handy, and nothing else. Conversely, a biology student may find it worthwhile to read the pages on USABO camp (40–42) and lab opportunities (50–57). It is exceedingly rare to find a student who participates in more than a handful of the opportunities we outline. Thus, any given student should expect *at most* a couple dozen pages of this guide to pertain to him or her.

2

GENERAL RULES AND GUIDELINES

1. Don't cheat.
2. Don't be complacent.
3. Waste a maximum of half your time. No one expects you to always be productive, but you probably waste more time than you realize online or playing games.
4. It is important you have time to relax and unwind. You should not take on more than you can handle.
5. Get sleep. There will be a tendency to stay up later and later to finish work.
6. Finish work ahead of time. Or, at the very least, by midnight the night before.
7. Each year, you will become more efficient at completing your work. Congratulations! Unfortunately, your efficiency will increase solely because of a similar increase in your coursework. Thus, the most important thing you can do to increase your time for outside activities is to complete your homework as soon as you get home from school. Unfortunately, you will most likely be tired and burned-out by the end of the day. Work through this.

8. Try to enjoy your time at TJ.
9. Play a sport if you aren't bad at it.
10. Although we encourage students to try many activities outside of their comfort zone, quitting after a season, semester, or year is not an indication of failure. Don't flounder around once you realize an activity is not for you; cut your losses and move on (assuming you have made no outstanding commitments to others).
11. To a certain extent, grades don't really matter. Try to get A's and A-'s. Don't worry about maximizing your GPA. Don't work harder than you need to for school. Extracurricular activities are more important. You will spend far less time on schoolwork if you have a strong math background and decent writing/BSing ability.

3

CLASSES AND CLUBS

Many of you were interested in STEM in middle school; that is why you are here! First, we recommend you identify what subject you find the most interesting. Some possibilities include math, chemistry, physics, biology, engineering (rocketry, robotics, etc.), or computer science. Students are generally introduced to STEM fields through either classes and clubs. Thus, we provide some advice for choosing your coursework and which clubs to participate in.

3.1 SUMMER CLASSES

Don't take classes you aren't interested in. The only exceptions occur in the summer before 9th grade. We recommend you do one of the following:

- Take Research Statistics. This aligns your math schedule with the school year.
- Get your 4th history credit out of the way. You will not regret it senior year, and it is a great way to meet your fellow classmates before September.

Do not take summer chemistry after 9th grade unless **one** of the following applies to you:

- You know ahead of time you really enjoy chemistry. Maybe it's from Chemistry Team or Chemistry Society. Just know that if you liked 9th grade biology, you're not necessarily going to like chemistry. They are very different courses.

- You want to take AP Physics in 10th grade. Physics in 10th grade is a great opportunity, especially if you are strong in math or have attended Physics Team.

- You believe you cannot spend your summer in a more productive manner, such as working on a fun project, conducting research, or studying for an Olympiad camp. In this case, summer chemistry can be beneficial (turning an otherwise unproductive summer into a learning experience). Still, you must be willing to work hard while your friends enjoy their lives, knowing full well your efforts probably won't result in any meaningful benefits long-term, save improved study habits.

If you only want to take summer chemistry because you get bored during the summer, see Chapter 5.

Note that you can now take AP Physics in sophomore year as an elective; instead of taking summer chemistry, you can take P.E. or a language online (e.g. Spanish 3 online) to free up an elective slot.

3.2 SKIP TESTS

If you are bored in your current math class, and want more of a challenge, you may wish to skip math courses. TJ offers three options to skip math courses:

- TJ Math 4 skip test (Offered in June to rising freshmen, in August to everyone else)
- TJ Math 5 skip test (Offered in August to everyone)
- BC Calculus Exam (Get a 5 on the Exam + Have A's in all other HS math courses)

If you wish to skip a math course, we recommend taking the BC Calculus exam, because getting a 5 requires a minimum of 70% correct, and it allows you to skip an entire year of math. This may be especially helpful to students who wish to take AP Physics and Multivariable Calculus concurrently. The other skip tests only allow you to skip a semester of math, throwing off your schedule. With that said, you should only skip a math course if you are confident in your mathematical ability. If you can't excel in a higher level of math, you probably shouldn't be skipping in the first place.

If, as a rising freshman, you are interested in computer science, we highly recommend skipping 'Foundations of Computer Science'. The skip test is available in August, and a disk of material is sent out in early June. You must apply in May, getting signatures from your math teacher and counselor. The forms can be found on the TJ CS website. You must score $\geq$90% to skip Foundations. This will require you to understand basic programming logic and Java syntax. You must be motivated enough to learn this material on your own between your acceptance in April and the exam in August. The primary way to learn this material is by working through the seven packets given on the disk. It is more than doable with no prior experience and requires only time commitment.

If you do not pass the exam or are unable to take the skip test, we highly recommend taking 'Foundations of Computer Science Accelerated', where you will learn Python for the first three quarters, and then rush through Java in a quarter. Generally, students who take Accelerated are already familiar with some Java, but not enough to pass the skip test. It is still possible to take this class without programming familiarity, and a few students do so. It is also possible to drop to Foundations if you find yourself unprepared. That being said, if you aren't interested in computer science, or if you haven't taken the initiative to at least dabble in computer science, Accelerated is probably not for you.

There are no other skip tests available at TJ. However, if you are advanced enough to take an AP exam in middle school (AP Computer Science A, AP Biology, AP Chemistry, etc.), TJ will allow you to skip directly to the Post-AP course (AI, Neurobiology, Organic chemistry, etc.). This is rare and extraordinarily difficult unless you are a genius (except for the APCS test, which is possible to take in 8th grade if you are introduced to computer science early enough).

Some might ask: Why skip courses when I can enjoy an easy A? Simply put, you should skip courses only if you care about learning more than grades. Spending a year in a class where you already know the curriculum is a waste of time, so skipping the course allows you to learn more. Another advantage of taking advanced courses early is to gain knowledge which can then be applied in competitions or research projects. Although a TJ education alone will certainly not prepare you for creating research projects or participating in Olympiad competitions, having a solid foundation early from a year-long class goes a long way in your success. This is why most students who do well in US-

APhO take AP Physics C sophomore year, most USACO campers take APCS freshman year, and most students who do well in USNCO take summer chemistry. These students are interested early on in the field, and take steps to accelerate their in-class experience, which greatly impact their performance in outside competitions.

3.3 AP PHYSICS

If you are unsure if you want to take AP Physics junior year, you should keep in mind the following things. If you are in Multivariable calculus junior year, the topics covered (gradients, line integrals, flux integrals, etc.) are used in AP Physics second semester. The vast majority of juniors in Multivariable calculus take AP Physics concurrently.

If you are in BC Calculus junior year, there are a few caveats. You should only take AP Physics if you did not need to study to do well in Precalculus. Math should have been easy for you through freshman and sophomore year. In addition, to perform well in AP Physics, you should learn some of BC Calculus beforehand. The BC Calculus Blackboard site is open to all; download the material before the end of the previous school year. Work through the first seven chapters before September junior year. A great alternative is to simply work through a Calculus textbook; the Art of Problem Solving Calculus book is highly recommended because it delves deeper into Calculus than the BC material in a compact 300 pages.

For all students considering AP Physics, know that physics differs from the previous science courses in that it is essentially applied math. You should enjoy math and problem-solving. You do not need to have enjoyed your previous science courses.

It will become apparent very quickly whether AP Physics for you or not. The workload is somewhat intensive and the first tests are very representative of your future performance. Unless you significantly change your time commitments or studying habits, do not expect your grade to rise after first quarter. Knowing when to drop is very important.

3.4 Other curriculum information

Freshmen making their course selections for sophomore year are often presented with the following elective choice: AP Biology/AP Chemistry or AP Computer Science. Choose one, or spend half your summer in summer chemistry to take both. We would like readers in this situation to be aware that if neither AP Biology nor AP CS interests you, some of the tech classes (Engineering Design, Prototyping, Robotics, etc.) may be more suitable, especially if you enjoyed Design and Tech. Few sophomores take these courses, partially because they do not have a GPA boost (Honors tech classes vs. AP CS/Bio), but also partially because they are not emphasized during course selection time. It is certainly true with technology classes that what you put into it is what you get out—they are notoriously easy grade-wise, and it is very easy to spend a year without retaining much knowledge. However, putting effort into technology classes will result in long-term practical technology skills.

Junior year is often the most stressful at TJ; students no longer have a free P.E. period, and physics is much tougher than biology or chemistry. We highly recommend juniors take at least one "easy course", that is, a course without much homework. For most, this means an engineering or computer science course, but any lab- or project-based class will do. Even the strongest TJ students eventually feel the crunch of APs and post-APs junior year; everyone needs at least one course to relax and unwind in.

Students enrolled in post-AP math courses (Multivariable Calculus, Linear Algebra, Complex Analysis, or Differential Equations) have the opportunity to dual enroll. Dual enrollment allows you to receive credit for the course as if you were taking it at GMU (the finals for these classes are GMU-written). Although the cost is significant ($400 per course), dual enrollment is useful, as it allows you to recieve credit for these courses at college, allowing you to take higher-level math and potentially graduate early. However, some colleges do not accept dual enrollment credits. Check with the college you plan to attend to ensure they accept dual enrollment credits *before* you dual enroll. If you are taking one of these courses before you know which college you will attend, call the schools you intend to apply to and ask them. When in doubt, assuming cost is not an issue, dual enroll—you won't regret it when you reach college.

3.5 ACTIVITIES AND CLUBS

Even more important than choosing your courses is choosing which activities to participate in. You cannot do them all. Sorry. It is far better to do 2–3 activities very well than 10 activities with mediocre results.

It's not hard to choose what you are interested in. There are a million and a half clubs at TJ—try them! Do not go to study halls. Waste few 8th periods at TJ. Once you find a club you like, go to meetings every week. If there are after school meetings, go to those. If you realize you don't actually like that club, then stop going.

Note that there will be a tendency to join clubs that align with your current coursework. For example, joining Biology Olympiad as you take 9th grade biology, Chemistry Team during your 10th grade, or Physics Team during 11th grade. Before commiting weekly to a club, consider the following: would you attend the club if you weren't currently taking a course on the subject? Joining Biology Olympiad, then Chemistry Team, then Physics Team, each for a year, gets you nowhere in all three subjects. Concentrate on clubs with subjects that interest you; you should not need a class to motivate you towards a subject which you are truly interested in.

Certain clubs are more valuable than others. Chess Club, for example, is a great place to play chess with your friends. However, you can easily do this outside of the club. Don't spend every Friday A&B playing chess, even if you really enjoy chess. Rather, attend clubs that provide experiences you cannot enjoy readily outside of the club. Sure, go to chess club, but one block a week suffices.

As with every example, there are exceptions. If you are training for chess tournaments, and want prolonged periods to play against the best in the school, by all means, attend 90 minutes of Chess Club a week. But for the vast majority, clubs like Chess Club are opportunities to just hang out with friends.

Certainly the majority of clubs at TJ fall into this category. There are a few clubs, however, that provide valuable learning experiences. We call these clubs *academic teams*. These *academic teams* offer more than your traditional club, and demand more from you as well. Academic teams are some-where between a club, a class, and a school team—open to anyone when they meet during 8th periods like other clubs, tend to be lecture-based, teaching students material they won't find in any class at school, and top club members often compete in competitions individually or as a school team. (We previously referred to academic teams as "legit" clubs, but we've changed the term since "legit" clubs is vague and open to misinterpretation.)

The most important aspect of academic teams is the unique learning experience they offer. Consider Physics Team. It is difficult to learn physics independently; Physics Team provides a unique opportunity for you to learn from experienced physics students. Obviously, 45 minutes a week of physics is not nearly enough to learn the subject. However, it is certainly enough to introduce physics topics to underclassmen well before they would otherwise encounter them in their junior year. Students who wish to pursue the subject further now have a year or two head-start on their peers. Thus, academic teams serve as starting points for students entering a field of science or technology, and provide valuable experiences even if you never attend after-school sessions or outside competitions.

By and large, academic teams derive their status from national competitions. By this, we mean that the national competitions drive students to dedicate significant time to the club year after year, thus creating a comprehensive learning experience for younger members. Academic teams provide an opportunity for you to hone your skills, and then demonstrate them on a national level. Try to participate in one academic team. If no academic team interests you, that's perfectly fine. That probably means there's no national competition in your desired field.

List of some academic STEM teams:

- Math Team
- Physics Team
- Senior Computer Team (open to everyone)
- Intermediate Computer Team (open to everyone)
- Freshman Computer Team (freshmen only)
- Machine Learning Club
- Biology Olympiad
- Chemistry Team
- Science Bowl
- Computer Security

We are certain there are other academic teams. This is by no means a complete list. However, the authors only have expertise in the fields of math, physics, computer science, and biology. Academic teams in the humanities fields (MUN, Quizbowl, Debate, etc.) are outside the scope of this guide. If you would like to contact the authors regarding our classification of a club, we are open to suggestions.

Note that you can always found a club if there is no club in your specific field. We caution against two things:

- Making a “club" version of a niche class. If you are interested in Parallel Computing, there’s already a class. A club is unnecessary.
- If no national competition exists, it will be *very* hard for your club to become an academic team. You will have to motivate 30 others to join your interest without providing them any tangible benefit.

A few further things to keep in mind about starting your own club:

- Your club should be centered a topic students will genuinely come to learn or enjoy.
- You should create rigorous and extensive material to teach students. This will be a time-consuming process, even with multiple officers. It is **far** more work to create a new club than to preside over an existing organization.
- Students are not inclined to learn from their peers. Lectures will only be attended by students younger than the lecturers.
- The inaugural year of a club is almost always "BS". It is very difficult to create new club lectures, competitions, or other presentations while simultaneously completing your school duties.
- Forms and paperwork will result in a shorter inaugural year for clubs. Most new clubs cannot start before Mid-November as a result.

Most students run for officer positions of a club at the end of their sophomore or junior year. Occasionally, a lower-level position (statistician/webmaster) will be filled by an enterprising sophomore. If you dedicate significant time to a club, participate (and place well) in the competitions, and can lecture or teach efficiently, you will most likely be elected to a mid-level lecturer position for junior year, and from there, captain/president for senior year. When given the opportunity to guest lecture, make full use of your platform. Ensure your teaching is engaging and informative, and your presentation is well-planned and thorough.

Many club elections are “elections". The current officers know which students are most qualified to lead the following year, and try to ensure a qualified candidate wins the “election". Thus, students have little to worry about come election season if they truly dedicate themselves to a club. The election mob will not sweep you aside to vote for their unqualified friends. Nevertheless, you should still try to make yourself known to the majority of the club. If the first time you see half your electorate is while giving your campaign speech, you most likely won’t be successful.

4

EXTRACURRICULARS

We provide a brief description of each of the STEM academic teams from Chapter 3. This information may be especially helpful to younger students who are unfamiliar with many of the clubs, activities, and competitions.

Simply attending one of these clubs during 8th period won't help you much. If you want to participate or place well in the national competitions each club offers, you'll need to spend significant time outside of school practicing and learning.

MATH TEAM

By Akshaj Kadaveru (VMT Captain 16–18)

Math Team meets Wednesday A and B blocks, plus certain days afterschool. At meetings we give lectures, hold practices, and participate in regional and national math contests. We also travel to compete in many big-name math competitions. Any TJ student who enjoys math is welcome to join the team, regardless of skill level.

Competitions we participate in include the Duke Math Meet (DMM), Princeton University Math Competition (PuMAC), Carnegie Mellon Informatics and Math Meet (CMIMC), Harvard-

MIT Math Tournament (HMMT), and the American Regions Math League (ARML).

Website: `activities.tjhsst.edu/vmt`

PHYSICS TEAM

By Franklyn Wang (Physics Team Co-captain 17–18)

Physics Team meets on Friday A blocks. Physics Team is stratified into A team, B team, and C team. A team's focus is to prepare for the USA Physics Olympiad exam. B team's focus is to prepare for the $F = ma$ exam as well as the AP Physics Exam. Lastly, C team's focus is cool demonstrations to get students interested in physics.

Physics Team competes in the Physics Bowl, Princeton University Physics Competition, the $F = ma$ exam, and the USA Physics Olympiad.

Physics Team officers are decided by appointment, NOT elections.

Website: `activities.tjhsst.edu/physics`

SENIOR COMPUTER TEAM

By Justin Zhang (SCT Captain 17–18) and Mihir Patel (SCT Co-Captain 17–18)

Senior Computer Team (SCT) meets on Friday A blocks. SCT, unlike the other two computer teams, focuses heavily on algorithms and data structures, in preparation for the USA Computing Olympiad. In addition, SCT sends teams of four to local algorithmic competitions such as VCU, UMD, and UVA's high school programming contests.

Meetings are generally split into beginner and advanced groups, which cover USACO Bronze/Silver and USACO Gold/Platinum content, respectively. Practice contests are occasionally held via the Codeforces platform.

In general, if you only have time to participate in one computer team, and you enjoy learning advanced algorithms and data structures, participate in SCT: achievements in USACO are generally valued over those of ACSL. Top USACO competitors go to USACO Camp, and from there the very best attend IOI.

With that said, SCT requires a lot of initiative. The vast majority of competitive programming skill is built off of lots of practice. SCT gives you lots of resources and opportunity, but getting good requires consistent practice and dedication. The best ways to improve are taking lots of Codeforces competitions and going through the USACO training pages.

Prior years' lectures can be found on the SCT website.

Website: `activities.tjhsst.edu/sct`

INTERMEDIATE COMPUTER TEAM

By Mihir Patel (ICT Captain 16–17)

Intermediate Computer Team (ICT) meets on Friday B blocks. ICT primarily focuses on the ACSL competition, competing in the tier above the freshman team. The lectures are specifically geared towards content on the upcoming ACSL competitions and are taught by the officers, who are almost exclusively juniors. ICT also participates in various algorithmic competitions.

ACSL is not very prestigious and not useful for resume-building. As a result, if you are good at competitive programming, it is not worth your time to come to ICT. With that said, if you are still getting into it and genuinely like ACSL's competition, ICT is a good club to be in.

The primary benefit from ICT is a fun trip to the ACSL competition if you make the team (in addition to potential officer positions). Making the team is not too challenging if you really care, and a bit of practice easily makes you competitive. As for being an officer, that's far more dependent on your charisma, dedication, and ability to teach. This is a decent position and often helps in being elected for SCT.

The ACSL competition focuses on computer fundamentals. Topics include number systems, bit shifting, etc. and the test is not complex at all. Even 45 minutes of practice before each test is more than necessary for preparation.

Website: `activities.tjhsst.edu/ict`

FRESHMAN COMPUTER TEAM

By Justin Zhang (Participant 14–15)

Freshman Computer Team meets on Friday A blocks, and is open exclusively to freshman. Freshman Computer Team focuses on general computer science knowledge in preparation for the American Computer Science League programming contest (ACSL).

Based on contests given throughout the year, the Freshman Computer Team selects a team to represent TJ at the ACSL All-Star Contest (junior division).

Freshman Computer Team does not have officer positions.

MACHINE LEARNING CLUB

By Nikhil Sardana (TJML Captain 16–18)

Machine Learning Club meets on Wednesday A blocks. Machine Learning Club teaches students the theory behind various machine learning algorithms. Topics range from decision trees and SVMs to Convolutional and Generative Adversarial Networks. ML Club also holds competitions most weeks, applying theory introduced in the lectures to real-world datasets. Many of the topics covered are frequently used in research projects at science fairs and competitions nationally, so Machine Learning Club provides a solid foundation for burgeoning researchers. In addition, officers actively mentor students with machine learning research projects at their request.

Website: `tjmachinelearning.com`

BIOLOGY OLYMPIAD

By Anish Karpurapu (TJBO Captain 17–18)

Biology Olympiad meets every Friday B block. During 8th periods, the officers teach advanced biology concepts to help prepare for competitions such as the USA Biology Olympiad and University of Toronto Biology Competition. On most Fridays after school from 4–6, Biology Olympiad meets to provide an additional opportunity for practice. After spending an hour individually working on previous exams, the officers go through the answers and explanations for each of the questions at the request of the club members.

Website: `tjbio.webs.com`

CHEMISTRY TEAM

By John Kim (Chemistry Team Captain 17–18)

Chemistry Team meets every Friday B block (though this is subject to change due to Mr. Kauffman's busy schedule). The majority of meetings are spent with lectures that first briefly review AP Chemistry material and then present more advanced topics that may appear on the Chemistry Olympiad and the Chem 13 News exam. Since the USNCO includes a lab section, a lab challenge is often conducted in lieu of a lecture so that all members can hone their practical problem solving skills.

Website: `activities.tjhsst.edu/chemteam`

SCIENCE BOWL

By Franklyn Wang (Science Bowl Captain 16–18)

Science Bowl meets during lunches, and is intended to select a team for the National Science Bowl competition. At the beginning of the school year, each student takes an exam. The top few students advance to a buzzer round, where the team is decided. There is a Regional competition in late January and a National Competition in mid-May. TJ has qualified for Nationals for the past 25 years. Teams which take first or second at Nationals win an all-expense paid trip.

COMPUTER SECURITY CLUB

By Neil Thistlethwaite (TJCSC President 17–18)

Computer Security Club (CSC) meets every Wednesday A and B block. Officers give a different lecture and associated practice problems each week, although the lecture is the same for A and B block. Topic categories include File Forensics, Web Exploitation, Binary Exploitation, and Reversing. CSC members compete in a variety of competitions, primarily Capture-the-Flag (CTF) contests. We also organize the CyberPatriot teams, and have historically done very well, netting top finishes in many competitions.

Website: `activities.tjhsst.edu/csc`

NON-TRADITIONAL CLUBS

- Sysadmins — Manage/Develop Syslab network and computer hardware.
- CubeSat — Design/Build TJ's satellite

OTHER

Other legitimate activities (which are not necessarily associated with clubs):

- HackTJ — TJ's annual hackathon. A fun way to spend 24 hours: eating food and building useless applications.
- MIT Battlecode — Month-long AI/battle strategy competition every January; TJ students frequently participate.

5

CARPE DIEM

Don't waste your time. If you like a certain subject in class, look for the 8th period and after-school opportunities. Don't be afraid to join a club in the middle of the school year—it's not too late, and you can't go back in time to join earlier. Look at club websites for lecture information and talk to the officers to catch up on what you missed. In general, however, try to join clubs as early in the school year as possible.

Whether it is math or biology or chemistry, we recommend finding at least one activity with a national competition (see academic teams section in Chapter 3), and working towards performing well at the national or international level. For most areas, this will take years of work. Do not participate or try for a national competition which you are not truly interested in. Not sure if you want to commit so much time towards an activity? You can always quit later. It's best to try and quit than to never try at all.

During the summers, either work towards a camp or complete some research/project. Look to Chapters 6 and 7 for camp and research advice, respectively. If you have neither the desire to work towards a camp nor the skill set for research, simply find a friend and complete a project in your area. You will learn valuable skills and working with a friend (in person, not online) is a motivator to hold up your end of the team and prevent laziness. Long term projects are as much a test of your ability to solve large problems as they are a test of planning and execution.

5.1 corporate internships

Some students find internships and work at start-ups or established companies during the summer (especially between junior and senior year). Depending on your field of interest, you may want to pursue a corporate internship. For example, if you are interested in web/mobile development, it can be highly beneficial to gain real-world experience creating applications in a corporate environment. With other fields, however, like pure math or physics, you are far better off conducting research, working towards a camp, or simply completing your own project. Few companies have high school internships that allow you to harness and apply your knowledge of the pure sciences. Regardless of your interests, ensure that you will have a meaningful role and gain valuable experience *before* accepting any job offers. Do not waste weeks of your precious summer slaving away on meaningless busywork for an extra line on your resume.

In terms of your resume, no one cares if you worked for <insert start-up> for 7 weeks between sophomore and junior year. Company name matters for internships, but few established companies are willing to hire high school students. Thus, choose an internship based on how useful the experience will be to you.

Before applying, contact older students who worked at the company in previous years. They will offer you advice on the application and interview process, as well as what to expect on the job site. Get multiple opinions whenever possible.

6

OLYMPIAD CAMPS

The International Science Olympiads are a group of competitions across the scientific fields open to students across the world. At each Olympiad, the top 4–6 students from each country compete against each other. Students can be awarded Gold medals, Silver medals, Bronze medals, or Honourable mentions for their performance. Since the United States is a large country, in general, we perform very well at the Olympiads. Most United States Olympiad participants walk away with Gold or Silver medals.

Since the United States is so large, simply qualifying for a U.S. Olympiad team (determining the top 4–6 students in a particular field) is a rigorous process and attending an international olympiad is a prestigious and rare accomplishment. For example, the last student from Thomas Jefferson to attend an international olympiad was Joyce Tian (TJ '17, IChO Silver Medal 2016). Before that, Janice Ong (TJ '15) won Silver at IChO 2015 and Will Long (TJ '15) won Gold at the 2014 IBO. Adam Ardeishar (TJ '19) will attend IMO 2018, the first IMO participant from TJ since Mitchell Lee (IMO Gold 11–12). In general, a TJ student qualifies for one of the Olympiads every 1–2 years. It takes years of preparation and intense studying to qualify for an international olympiad.

Although there are more than 5 International Olympiads, the International Mathematical Olympiad (IMO), International Physics Olympiad (IPhO), International Olympiad in Informatics (IOI), International Chemistry Olympiad (IChO), and International Biology Olympiad (IBO) are far more prestigious and important than the others. Thus, this chapter focuses on the U.S. selection process for these Olympiads.

Each Olympiad has a different process, but in general they begin with a few qualifying tests, each far more difficult than the last, and culminate in a camp, in which the top 2–3 dozen students are sent off to a university for a few weeks in May/June to determine the 4–6 team members who will represent the United States. Thus, the general process for reaching an international olympiad looks like this:

Open Exam $\rightarrow$ Semifinal Exam $\rightarrow$ Camp $\rightarrow$ Olympiad

At each stage, perhaps the top 5% will qualify. Some camps have more than 2 qualifying tests. Others have tests after the camp to determine the Olympiad team. For most Olympiads, reaching the "Semifinal Exam" level of the process requires about a year of coursework or studying. However, reaching the camp stage is far more difficult, and many students study on-and-off for years without ever reaching a camp. The notable exception to this general Exams $\rightarrow$ Camp process is the USA Computing Olympiad, which eschews exams for 4 programming tests through the year.

For high school students, attending a camp in their field means nearing the pinnacle of achievement. The five camps listed below have rigorous standards to gain admission, and just attending a single camp is a significant accomplishment.

Attending the USABO Camp is roughly as difficult as attending the USNCO Camp. Both are more difficult to attend than the USACO camp, and both are less difficult (and therefore less prestigious) than the USAPhO camp. All aforementioned camps are less difficult and prestigious than MOP.

6.1 MATHEMATICAL OLYMPIAD SUMMER PROGRAM

By Joshua Lee (MOP 17) and Akshaj Kadaveru (MOP 15–16)

TJHSST dedicates one day in February for the AMC 10/12 A, a nationwide math competition for high school students. AMC 10 is only open to freshmen and sophomores, and the AMC 12 is open to all students, but a student can only take one of the two. AMC 10/12 B is also offered, but this will be done during an 8th period instead of during the school day.

Placing within the top 5% on any AMC 12 or the top 2.5% on any AMC 10 will qualify a student for the AIME (American Invitational Mathematics Examination). The AIME takes place in March, and around one hundred TJ students participate yearly. A combined USA(J)MO index is then calculated, and approximately 250 students with the top AIME + AMC 12 indices qualify for the USAMO, and approximately 250 students with the top AIME + AMC 10 indices qualify for the USAJMO. If a student qualifies for both, they must take the USAMO. Qualifying for USA(J)MO is already a significant achievement, only done by around 15 TJ students every year. It is important to know that Olympiad Math is proof-based, which means that it is quite different from other competition math (such as the AMC or the AIME).

USA(J)MO is held for two days in mid-late April. The top 12 performers of JMO (short for USAJMO) are the Winners, and they qualify for Red MOP. The next top 12 performers are given the title of Honorable Mention (HM), but they aren't given MOP qualification unless under special circumstances (for instance, if a JMO winner is in middle school and placed in the lower half of the winners, then the top HM is invited to MOP). The top 12 performers of USAMO are the Winners, and they qualify for Black MOP, unless they are a senior and did not qualify for the IMO team. The winners are invited to a ceremony in DC in June, immediately before MOP, and the top 3 performers are awarded scholarships. The next 12 performers are the HMs, but it really is just a title. Instead, the top 18 performing non-winners who are juniors or younger are invited to Blue MOP, and the next 15 students who are freshmen or sophomores are invited to Green MOP.

MOP is the training camp for the USA IMO Team, and is held for 3.5 weeks in June. MOP is divided into five colors: Black, Blue, Green, Red, Pink. Black is the highest level, containing the members of the IMO, winners of USAMO, past winners, and international students (Po-shen invites 10–15 international students to MOP every year). The next highest level is Blue MOP, serving as a bridge between Red/Green and Black MOP. The third level is Green/Red. The two colors are meant to be the same level, with the difference coming from the fact that Red MOP consists of JMO winners and Green MOP of high USAMO performers. Recently, this changed to Red MOP consisting of first-time MOPpers and Green MOP consisting of returners, although this rule wasn't enforced entirely. Rules on Green/Red

MOP change continuously, but the two levels always have lectures of similar levels and take the same tests. The last level is Pink MOP, reserved for the top performing girls on the USA(J)MO who didn't otherwise qualify for MOP. Pink MOP serves to train and select students for the EGMO, and around 10 girls are selected each year. Pink MOPpers usually attend Red/Green MOP lectures and take Red/Green MOP tests.

At MOP, students continually take MOP tests, which are tests similar to the IMO and intended for students to improve both problem-solving and solution-writing. On the last week, the students are administered the TSTST, and the top 25-ish contestants are selected to be part of the TST group for the following school year. These students, along with the Pink MOPpers, take five additional contests throughout the school year to determine the national IMO, RMM and EGMO teams.

Although there are many great books on competition math out there, there is not one book that will take a student right to the doorsteps of MOP. Qualifying for AIME can mostly be done by continually solving past AMC problems, and one can get near USA(J)MO qualification by repeatedly solving past AIME problems. A student must have extensive knowledge in all four major fields of competition math: Algebra, Geometry, Combinatorics, and Number Theory. USAMO qualification barely requires a student to solve 10 problems correctly on the AIME, but a student with great understanding of the topics should easily be able to solve all 15 problems.

Doing well on the USAMO requires slightly different training than for the AIME, as the focus is shifted to proving a mathematical claim rather than solving for an answer. There are many resources that can help guide a student to learn more both online and in text, but there is nothing more important than practice. One can know everything they need to about math and still fail to solve the easiest USAMO problems without any practice. There is an extensive problem archive in AoPS, which offers an endless number of math problems that a student can use for practice. Varsity Math Team also offers many opportunities to improve mathematical skills, including lectures and practice contests. Even with these numerous resources, MOP qualification requires a combination of dedication, talent, self-confidence, and luck. Do not take improvement for granted, regardless of how much effort you put in.

6.2 USA COMPUTING OLYMPIAD CAMP

By Franklyn Wang (USACO Camp 17–18)

The USA Computing Olympiad is the premier computer science competition at the high school level. There are four contests every year, in December, January, February, and March, as well as four divisions, which are Bronze, Silver, Gold, and Platinum. Each contest is three problems, and you are given four hours to solve them. All students start in the bronze division. The ways to get promoted to another division are:

1. to do reasonably well and wait for the contest results to come out or

2. solve all three questions and be promoted immediately, allowing you to start with a new clock on the next contest immediately.

The students who perform the best on the March Platinum test are typically invited to USACO Camp.

At USACO camp (hosted at Clemson), you are either a Guernsey (lower division, not eligible for IOI) or a Holstein (upper division, eligible for IOI). The Guernseys receive lectures and take some of the IOI selection contests (3 problems / 4 hours), whereas the Holsteins take all of the IOI selection contests.

Students should be able to reach USACO Gold division in a couple contests with only knowledge from their APCS classes. Many of the lectures in Senior Computer Team or standard dynamic programming coursework will help you reach Platinum in less than a year after APCS. Note that USACO camp is the easiest to make out all the camps listed in this document. Most students can make camp with less than two years of competitive programming experience, while other camps (like MOP) require far more years of involvement. In addition, the younger you are, the easier it is to reach USACO camp; camp selections are not objective, but rather age-adjusted. Most students from TJ who make USACO camp do so in their sophomore year.

Starting early is key for USACO success. The majority of students who do well in USACO contests take APCS and start attending SCT in their freshman year. See the section on skip tests for more information on skipping Foundations.

Some good resources to prepare for the USACO competitions include `github.com/bqi343/USACO`, `codeforces.com`, and of course `usaco.org`. Some good benchmarks for USACO skill:

Codeforces Rating	USACO
1200	Silver
1400	Gold
1600	Platinum
1950	Guernsey
2200	Holstein

6.3 USA BIOLOGY OLYMPIAD CAMP

By Anish Karpurapu (USABO Semis 15–18)

Every year, TJ allows for students to take the USA Biology Olympiad Open Exam during two 8th period blocks in February. This exam is open to all students, and signups occur a month earlier. It is a 50 minute, 50 question multiple choice exam with some questions having more than one answer. Each question is worth one point, and there is no penalty for guessing. The exam is split among seven topics, each of which consist a specific portion of the test:

Topic	Portion of Exam
Animal Anatomy/Physiology	25%
Cell Biology	20%
Genetics and Evolution	20%
Plant Anatomy/Physiology	15%
Ecology	10%
Ethology	5%
Biosystematics	5%

Although the exact percentages sometimes deviate, they generally hold on the whole.

The top 10% of test-takers then advance to the second round and are eligible to take the USA Biology Olympiad

Semifinal Exam. Usually around 20–30 kids from TJ qualify for this exam every year. This rigorous exam is 2 hours long and consists of three parts. Both Parts A and B consist of 60 multiple choice questions each, but Part B is much more difficult in that some questions can have multiple answers and the questions involve a much deeper understanding of biology. As a result, each question in Part B is worth two points as opposed to the one point questions in Part A. However, this was not true for the 2018 exam, in which all multiple choice questions were worth one point. Neither section has a penalty for guessing, although the rules may vary from year to year. Part C varies greatly from year to year and can range from one long essay question to numerous short answer questions.

The top 20 performers on the Semifinal Exam are then invited to the USABO National Finals where they undergo 10 days of instruction from professors, researchers, and other experts in biology followed by two days of rigorous testing. The practical exam is six hours and tests laboratory skills while the theoretical exam is a three hour exam with multiple choice questions in the format of Part B on the semifinal exam. The top scorers from these exams then go on to represent the USA at the International Biology Olympiad.

To study for these exams, it is highly recommended to study *Campbell Biology* as majority of the content can be traced back to this book. Although mastery over this book should be enough to make the semifinal round, ancillary texts such as *Biology of Plants* by Peter Raven and *Molecular Biology of the Cell* by Bruce Alberts provide much more depth and specificity. A website created by former Biology Olympiad campers, `studyoflife.org`, is a great tool for students as it contains numerous useful handouts and problem sets. Open and semifinal exams from previous years are also available on the internet and can be easily found with a quick Google search. These are invaluable resources to gain experience with the format and pacing of the exams.

6.4 U.S. National Chemistry Olympiad Camp

By John Kim and Aaditya Singh (USNCO High Honors 17)

Though officially the Chemistry Olympiad begins in March, this competition is unique in that it restricts the number of people who can qualify from each school. To this end, TJ runs two multiple-choice qualifying tests for prospective Chemistry Olympiad participants. The first is held in January, with a focus on rapid problem solving for relatively less complex questions. The second is held in February and allows for an ample 90 minutes, but features more difficult problems. Both exams vary in number of questions from year to year, but the second exam can be expected to be more questions, but generally easier to complete due to less computational and more concept questions. The scores from both exams are added with a 1/3 weighting for the former and 2/3 for the latter, and only the top scorers are permitted to take the Local exam. This is usually around the top 17–20 scorers, depending on how many spots are available for TJ students on a given year.

The Local exam is a 60 question, 110 minute multiple-choice test. The majority of these questions can be prepared for simply by paying attention in AP Chemistry; the level of difficulty and depth of knowledge generally does not surpass that of the TJ curriculum, though there are some exceptions. The local exam will include 1–2 questions regarding chemical trivia, laboratory techniques, and biochemistry, which are not as emphasized in the AP curriculum. However, these questions are not difficult and can be prepared for by taking previous exams, as topics are often repeated. Another key point is that questions come in the same formats from year to year (i.e. question 60 is **always** biochemistry and the 55–59 are always organic chemistry). As a result for trivia questions are past exams. In terms of textbook, the AP textbook (Zumdahl) should suffice, although most experienced campers recommend Atkins Chemistry for general chemistry review.

As before, the number of participants who advance from the Local exam to the USNCO per school is restricted. Only the top two scorers from TJ on the Local exam will be allowed to take the USNCO in April. As a result, it is essential to be extremely thorough and not make silly mistakes on the local (practice makes perfect!). From TJ, the difference in qualifiers can often come down to a single question. Also, the scores from the first two rounds are not factored in to picking the two students who take USNCO.

The USNCO exam consists of 3 parts. Part I is a 60 question, 90 minute multiple-choice test, very similar in style to the Local exam (except the questions are much harder). Part II is a free-response exam, consisting of 8 problems to be solved in 105 minutes. As with all previous exams, the range of topics is unchanged; there are few entirely new topics that must be learned. However, depth of knowledge is more important. Part III is the lab practical, which TJ students are often the least prepared for. This consists of two problems to be solved by designing and conducting an experiment with given materials. The top 20 scorers of the USNCO attend study camp.

Before delving deeper into preparation, it's important to take some time to learn about the grading. The grading outlined in this section is not an official statement made by the USNCO people, but grading is believed to work this way by most campers. Of the 3 part USNCO, only the multiple choice exams of all students are graded. From these multiple choice exams, the top 150 students are given Honors. Furthermore, their free response sections are now graded. A composite of free response and multiple choice is used to determine the top 50 students, who receive High Honors. Then the lab portion is graded, and a composite of MC/FR/Lab is used to determine the top 20 students who are invited to the study camp. The multiple choice portion is worth 75 points (each of the 60 questions being weighted 1.25 points), free response is worth 100 points (with question weights, specified on the round, varying based on difficulty and number of parts), and the lab section is worth 25 points (12.5 per lab question). A large part of your composite as a result is free response, and this is what most prospective campers tend to focus on. However, one should ensure an ability to perform well on multiple choice (so that your free response actually gets graded) as well as decent performance on the lab (which pretty much acts like a tiebreak for borderline campers).

In terms of textbooks/preparation for the USNCO, Atkins *General Chemistry* should suffice for most of the test. Most campers refer to a supplemental textbook for organic chemistry (most textbooks are fine, but Clayden is a favorite). Beyond these, the practice exams on the website are extremely helpful. In general, the USNCO requires deeper knowledge of theory (Molecular Orbital Theory, lanthanide contraction, and other post-AP topics) as well as more advanced techniques (like steady state equilibria).

Like the local exam, USNCO also follows specific structure (i.e. multiple choice questions are grouped by topic, with roughly the same number of questions in each topic from year to year). Free response questions also follow a structure (the last question, 8, is **always** organic chemistry).

6.5 USA PHYSICS OLYMPIAD CAMP

By Franklyn Wang (USAPhO Gold 17)

The USA Physics Olympiad begins in late January, with the $F = ma$ exam. The $F = ma$ is a 75-minute, 25-question multiple choice test. This exam is mostly mechanics, along with some fluid mechanics and wave mechanics questions, which is ideal for students who just finished their first semester of AP Physics. The top 10% of scorers, which is usually about 300 people, advance to the next round. The cutoff is usually around 16–17 questions correct, but some years it has been as low as 14 questions, and sometimes as high as 19 questions.

The next round is the USA Physics Olympiad, which covers many topics, including Thermodynamics, Relativity, Mechanics, Electricity and Magnetism, and occasionally Quantum Mechanics. There is an A and a B section. The A section is a ninety-minute test with four problems, each worth twenty-five points. One will be on Mechanics, and one will be on electricity and magnetism. The other two are usually thermodynamics and relativity, but occasionally there will be a curveball. The B section is a ninety-minute test with two problems, each worth fifty points. One is Mechanics, and one is on electricity and magnetism. These questions are essay questions, and each is graded primarily on the accuracy of the ideas, rather than the accuracy of the answers.

Of these contestants, about one-twelfth receive gold medals, one-sixth receive silver medals, and one-fourth receive bronze medals. Another one-fourth receive honorable mention status. Out of the gold medals (which number thirty to forty), twenty of them attend the training camp. Multiple factors are considered, like whether or not they have conflicting summer camps (like RSI, USACO Camp, or MOP) and their grade (11th graders are favored).

Finally, at the camp, students take an exam which mocks the International Physics Olympiad: a theoretical and experimental exam, each five hours long. The theoretical portion consists of three problems, which include all topics from the USAPhO, as well as basic fluid dynamics. The experimental portion requires intimate familiarity with experiments.

In order to study for these contests, we recommend taking AP Physics in 10th grade, teaching you the basics of mechanics and E&M. Ideally, you should be able to make it to the USA Physics Olympiad in 10th grade and get a medal. Then, the next summer you should spend time carefully reading the following three books:

1. *Fundamentals of Physics*, by Halliday, Resnick, and Walker 10th edition.

2. *Electricity and Magnetism*, by Morin and Purcell

3. *Introduction to Classical Mechanics*, by Morin

The second and third books are not as gentle as their titles sounds. The exercises are very important to work through—you may very well see the exact same problem on a competition! The 1st book is more of a catch-all, and would helpful to read during 10th grade while taking AP Physics. Chapters 1–13 are the core material for the $F = ma$, but material from Chapters 14–17 is becoming more and more frequent, so we recommend that you read those too. The E&M and Thermodynamics Chapters are 18–33. There is some cursory introduction to other fields in the later chapters, which are however deficient.

The second book is recommended for doing well in the USA Physics Olympiad and beyond. Working through the problems is incredibly essential, less so reading the content.

The third book is also recommended for doing well in the USA Physics Olympiad. Other than chapters 9 and 10, the problems are very good and will be greatly useful in developing good intuition. Furthermore, the relativity chapters 11–14 are the best anywhere.

If you have time, you may also consider reading *Thermodynamics* by Fermi, since it provides a somewhat different perspective. Finally, in terms of problems, obviously you want to work through the past USA Physics Olympiad problems, but there aren't many. We recommend doing the theoretical portions of the International Physics Olympiad problems for this. Make sure to look up concepts mentioned in the solutions that you don't know.

If you follow these instructions, you will definitely be able to get a USA Physics Olympiad Gold Medal, and probably camp as well.

6.6 OTHER CAMPS

You will not find significant following for the other U.S. Camps/International Olympiads at TJ. If you are interested in one of the other Olympiads, know the following things:

- They are less prestigious than the above camps.

- You will have to study entirely independently of TJ. Few in-school resources exist for the other camps.

7

RESEARCH PROJECTS

Whether no Olympiad camp exists in your field, or you simply do not care for competitive math/programming/biology/chemistry/physics, research projects are a great way to show your depth of knowledge, problem-solving ability, and long-term planning skills. Performing well on the national or international stage of research competitions is comparable to making some of the more difficult camps.

The majority of research projects are conducted during the summer. This is because it is difficult to maintain your schoolwork and a full-time research project concurrently. In addition, most deadlines for competitions occur in the fall or early winter, and some require research papers. While it is certainly possible to write a research paper during the school year, conducting actual research is better suited to the summer months.

The first section of this chapter covers lab research and popular internship programs. The second section focuses on prestigious research programs, and the third section covers independent research. Lastly, we take a look at popular research competitions, which allow students to win prize money and demonstrate the quality of their research on a national or international stage.

There's a lot of information in this chapter, and we barely scratch the surface of research opportunities available to you. The main takeaway is this: *don't waste your time*. Find a topic you love, whether its building a drone or writing efficient algorithms or splicing genes, and work for a couple hours each day (or more during the summer). **It doesn't matter where you do your project, whether it's in a lab or your garage or a prestigious research program.** Let your work speak for itself. If you have the resources, embark on the project.

That's not to say there aren't advantages of working in a lab or at a research program. A lab will offer you a more structured environment, multiple mentors, and professional equipment. But your project topic will be at the whims of your superiors, and you may end up working on a small part of a much larger research endeavor instead of your own project.

7.1 WORKING IN A LAB

If you are interested in the biological or chemical sciences, unfortunately, you will have to work in a lab to conduct research. There is simply no other way for you to have the resources and equipment to conduct significant research. The JUMP lab at TJ provides resources for underclassmen laboratory resources, but, as mentioned earlier, conducting research during the school year is exceedingly difficult. It's possible, but improbable, for a JUMP lab project to be truly successful. To be fair, it's difficult for any project to be successful, but having a mentor with years of experience in the field is generally a good way to choose projects with a higher likelihood of success.

We provide information on two popular lab programs: NIH SIP and ASSIP. A third program, SEAP, is also popular among TJ students, and provides the opportunity to work at a local naval research lab. Please remember that your experiences will differ greatly based on your particular field of interest, lab, and mentor.

Of course, there is always the option of emailing professors at a local university to see if they are willing to take on a high school student. Find a professor who's done work in an area you are interested in, and keep the email short and sweet. Since you're from TJ, they will know you are somewhat competent, but email quite a few professors regardless, since the vast majority will turn you down.

The tried-and-true saying holds: *It doesn't matter where you work, it matters what you do there.* Keep in mind the following points when deciding where to work:

- You are truly interested in the project you will be doing over the summer.
- You have a significant role in said project. You should not be just a lab monkey or data collector.
- Commute time and transportation. A metro for an hour is far worse than a car for half the time, especially when you have to do it twice a day, every day.

Last of all, if you plan on submitting research to a research competition, think about how the finished project would fare at competitions, and which parts you would be allowed to present. You must be the primary researcher of a project to present it at a competition, or have worked on a large part of the project. If you have only worked on a small part of a larger project, you can only present the part of the project you worked on, which in general does not work well. Saying “I pipetted solution for three months while the rest of the team did the hard stuff" won’t get you anywhere. A general rule of thumb: if you wouldn’t be the first author of the research paper, you can’t present the project at a research competition.

In general, successful biology/chemistry research projects don’t come from working in a lab with many others, but rather specialized research programs (like RSI), working one-on-one with a mentor in a lab, or independent research after school. That’s not to say that working in a large lab or a part of a large project won’t give you valuable experience, it just won’t give you a project that succeeds in research competitions. Again, all of the advice in this paragraph only applies if you wish to submit your research. In general, it is recommended, since research competitions can lead to prestigious and large awards, but submitting is certainly not required. Most students do not submit their summer work to research competitions.

7.1.1 *NIH Summer Internship Program*

The NIH Summer Internship Program (SIP) is a popular place to perform biology-related research during the summer. The application process begins early (November–December), and it is up to you to email researchers and ask them if they have a position available (best results come from emailing those who have previously taken high school students). Note that the long commute (>1 hour on the metro, no parking for HS students) and low pay ($12/hour) are downsides to this program. Some students even work unpaid if the lab they desire does not have a paid position.

Most students end up performing wet lab research under a mentor, usually a post-doc or staff scientist in the lab, rather than directly under the Principal Investigator. The first week of the internship is primarily composed of literature review and reading past papers produced by the lab to gain a solid background on the basis of the research performed in the lab. For the next few weeks, students conduct research, usually performing numerous trials of an experiment after their mentor demonstrates and explains the procedure. A large portion of the internship then consists of performing these procedures, which can include qRT-PCR, gel electrophoresis, PCR, western blotting, and so on. The internship culminates in a poster day where interns present their research to PIs, staff scientists, NIH employees, and other students.

If a student's work is part of a larger project by their mentor, which is later published, the student may get their name on the paper. This is a great accomplishment, especially if the paper is published in a prestigious journal. However, whether a student's name gets on a paper or not is largely up to the individual mentor. Some mentors are nice and slap interns' names on their papers, others will only do so when interns have significant contributions to the research. The vast majority of high school interns at the NIH do not get their name on a publication.

If you are interested in computational biology (as opposed to wet lab research), working at the NIH may not be helpful at all. Although the NIH has a supercomputer (which high school students can access with a bit of paperwork), TJ's computer resources will generally suffice for most computational biology projects. In addition, most datasets are public, so unless your mentor has access to private datasets, you will be working with publicly available data (and thus you will have to beat every previous algorithm in order to have novel research). However, the NIH name lends some prestige, and in general your work will be interesting. As a rule of thumb, if your sole computer science interest is in computational biology, then the NIH may be for you. However, if you are interested in computer science, and computational biology is just an interesting application of CS, then the NIH is most likely not for you.

The Application Process

The application process is fairly long. Information for the traditional summer internship program is available `here`. Normally it begins in December. You need two teacher recommendations, and you will need to budget enough time for you to fill out their forms and for them to write the recommendation.

However, if all you do is fill out the application, you won't get anywhere. No one will find you. Instead, you have to email people at the NIH who did work in the field you are interested in. Look through the PDF brochure of the previous years' Summer Poster days (2017 available `here`) to see which investigators took high school students in the field you are interested in.

Eventually, if your interest is in a niche, you will run out of people that took high school students and you should email researchers who may not have taken high school students or who work in tangential fields. Keep in mind that your greatest chance of success is always with a researcher who has taken high school students previously.

You won't hear back from 70% of the researchers you email. They're busy people. Roughly 20% will tell you "Sorry, I'm not looking for high school students", or "Sorry, my slots are filled this year". If you are lucky, perhaps 10% will respond positively to you and you might have an interview over Skype/Hangouts (or even in person). Even after an interview, you may not get the job (tighter funding during a Republican administration is an oft-cited reason for lack of available intern positions). In general, it is recommended to email 30–50 people.

After you are accepted, there are numerous forms to fill out (this is the government, after all). Once you get to the NIH, make sure you fill out the metro reimbursement form as soon as possible, or you will be paying hundreds over the course of the summer just to commute to work.

7.1.2 *ASSIP*

By Eric Lin (ASSIP 17)

The Aspiring Scientists Summer Institute Program (*ASSIP*) is a 7.5-week-long summer internship held at George Mason University (predominantly at the Fairfax campus). Stretching from the last week of June to the first week of August, student interns work directly under the mentorship of George Mason professors and post-doctoral and doctorate researchers. The disciplines range from computer science and chemistry to the physical and life sciences; there are 19 different fields of study, each with multiple possible professors as mentors. Thus, there is a plethora of possibilities.

However, the wide range and massive size of the program are a double-edged sword. Since there are so many mentors, their teaching style and quality covers a wide range as well. Rest assured, all mentors are professors (you won't be paired up with a doctoral student), so they will have decent experience with guiding college students through research. Unfortunately, some may view *ASSIP* interns as simply interns and not full-fledged researchers, and will give you simple projects to work on. These may be fun professors to hang around and work for, but let's be real—the reason you're doing summer research isn't to primarily have a fun time. It's to truly experience research—perhaps for the first time—and the end goal should be something tangible—a paper and poster at the very least, preferably submitted and accepted at research conferences and journals.

The mandatory end product of all *ASSIP* research projects is a standard research poster. At the end of the first or second week of August, there will be a showcase of every *ASSIP* project on stage at George Mason. However, as stated before, this is the **minimum** requirement. Thousands of high school students "conduct research" every year. The vast majority of this research ends up on a poster. Sure, a poster looks impressive at first glance; it may look far prettier than a bland research paper. Yet, in my opinion, a solidly and professionally written research paper is a must for all legitimate research. Not only does it present your work in a professional manner, having a research paper ready to go is extremely useful for your future—you can upload it to colleges as supplemental material, submit it to competitions such as STS or Davidson, and even cite it during job or college interviews. I highly encourage you to show initiative and ask your professor in the first few weeks about your intent on writing a legitimate, professional research paper. This will indicate to your mentor that you don't want to be like most high school interns and piggyback on a graduate student's project, or run a small, insignificant experiment, but instead that you truly want to conduct research and contribute to current research efforts.

The ASSIP Application Process

Regarding the actual *ASSIP* application, it is not very long nor time consuming to complete. If you have completed applications for RSI, SEAP, or similar research programs, the ASSIP application should be a breeze. First, the entire application is on the website (`here`) pretty much all year-round, and the application almost never changes from one year to the next. Moreover, the deadline is in **the first week of February**, which is after most other applications. However, I would highly recommend starting the application process much earlier. As with NIH, contacting the researchers—in this case, GMU professors—is of utmost importance. It is trivial to search up the emails of professors (all have GMU-associated web pages) and it doesn't take long to send emails to 10 or 15 professors. I suggest emailing either right before or after winter break.

The point of reaching out through emails is to give you a huge advantage in the application process; the professors are the ones that select and admit interns. Furthermore, Stage 2 of the application process is an interview with the professors, and if you have already corresponded through emails, it will be much less stressful than talking to a complete stranger. Think about it this way—if you contact 15 professors and 5 like you and would like to take you on as a student, you have in effect flipped the system. Now, you get to choose which lab to go to for the summer (this is similar to the college application process for top students; in the end they're the ones choosing colleges, not the other way around).

7.2 RESEARCH PROGRAMS

Most research programs and camps are useless; you are better off working on your own. Any research camp where you have to pay any money (except, perhaps travel costs) is, in general, not recommended. Perhaps the one exception is the `Simons summer research program`, which is a worse version of RSI, and costs $2,000. Research programs at universities which you may wish to apply to in the future are useless—they do not meaningfully increase your overall admission chances. However, a couple research programs are actually useful and prestigious.

7.2.1 *Research Science Institute*

By Franklyn Wang (RSI 17)

The Research Science Institute, held at MIT, is the most prestigious high school research program. It annually admits fifty domestic students and thirty international students to do research with mentors in the Boston Area, hailing from Harvard, MIT, Northeastern, Boston University, as well as companies. Students stay at Masseh Hall, at MIT, for six weeks. The program is entirely expense-paid.

The Application Process

Let's be real, knowing about RSI is meaningless unless you can get in. From what we understand, there are two primary routes to getting in.

1. The first route is the research route. This route likely requires you to make ISEF as a sophomore or become published in a journal as a coauthor. Both of these

generally require finding a good internship the summer before your sophomore year (although independent projects can certainly find success in these competitions). The research route is generally the route taken by most people who attend. However, a word of caution: if you take this route, you must make it clear in your application that you think you would get a lot out of RSI, and that you would rather go to RSI than continue your winning project.

2. The second route is the competition route. This generally requires one to qualify for a camp (or just barely miss it). You also need a strong recommendation letter from a teacher at TJ.

RSI Itself

During the first week, students are treated to classes from professors, intended to broaden their perspectives. The next four weeks are mentorship, where students work together with their mentors on their projects. The last week is “Hell Week", when students write their papers and presentations. Sprinkled throughout are lectures from distinguished professors, like Pardis Sabeti (Broad Institute Professor) and Eric Maskin (Nobel Laureate in Economics)

Another advantage of RSI is that the adults who direct it advocate for students to be accepted to the colleges of their choice. The results show. All but one domestic student from RSI 2016 who applied to MIT was accepted.

7.2.2 *PRIMES-USA*

By Joshua Lee (PRIMES-USA 17)

PRIMES is an opportunity for high school juniors to experience research in math, computer science or computational biology. Students partner up with mentors, who can be graduate students, lecturers, professors, or other professionals on the topic. The program is hosted by MIT, and applications are open until mid-November to early-December to high school juniors (or younger for those who intend to graduate early). The computer science programs are only available to Boston students, while the math program (PRIMES-USA) is available nationwide.

About 20–30 students nationally are selected annually for the math program, although this number has grown in recent years. A student is paired up with a mentor in mid-January soon after they are notified of being selected for the program, and the first few weeks are meant for reading, where the student familiarizes themselves with the subject. They start doing the actual research shortly afterwards, usually meeting with their mentor at least once or twice a week, although this number differs greatly from student to student. There is a convention in May, where all PRIMES students meet at MIT and present on their problem, as well as their progress and where they're headed in the future. The PRIMES program continues yearlong, although students are given great leniency in their schedules from this point on, so that it doesn't conflict with any possible summer plans.

Merely being accepted to PRIMES is an indication of excellence, and it is regarded highly when applying to college, particularly for MIT. However, PRIMES doesn't guarantee you a ticket to MIT; please don't apply to the program just to raise your chances to get into MIT. PRIMES also offers students exposure to math beyond high school, or an alternative to competition math, which may help guide the student's choice of career. Lastly, most PRIMES students submit their research projects to competitions such as Siemens, and often win prizes (as did Franklyn Wang, a contributor to this book).

7.3 INDEPENDENT RESEARCH

Most labs will be reluctant to hire freshmen or sophomores, and research programs are geared towards juniors and seniors. For example, PRIMES takes place during your junior year, and RSI the summer after. Thus, your initial research will generally be independent. Independent research offers the freedom to choose your topic, but you will often be constrained by resources.

Some fields of research are more accessible than others because they require fewer resources. Computer science research is especially accessible as a TJ student due to the free high-performance computing offered at TJ. The GPU and CPU clusters can be accessed via SSH during the school year and summer. In addition, several cloud computing platforms offer free credits. Google Cloud Platform gives a free $300 in credit to anyone with a credit card (the card is not billed after the credits run out), and Amazon AWS gives $150 with a `.edu` email (however, you must be 18, and they do ask for verification).

The Github student pack is available to anyone (use your `tjhsst.edu` email), which gives you free private repos while you are a student. The Github student pack gives additional AWS credit.

Any computer science or computational simulation project can certainly be conducted from your own home. Any algorithmic research, mathematics research, or theoretical work which requires little resources can be done independently (of course, theoretical work is very difficult to conduct without a mentor through a research program like PRIMES-USA). In addition, if you have the engineering supplies, an engineering project can be conducted from your own home (know your equipment and budget restrictions). In general, *any research which does not require large, expensive equipment can be done in your own home*, independently.

However, it should be noted that no matter your field, without a research partner to keep you in check, it is very easy to waste the summer away unless you are extremely motivated or have previous project experience. Therefore, we recommend meeting with a research partner in person for a set time every day during the months of your research project.

You should enjoy whatever project you pick, and the results (awards, prizes, recognition, etc.) will follow. Yes, it's true: some topics are far more likely to win awards than others. Projects involving disease diagnosis or water quality or computational biology generally lend themselves better to science fairs and competitions than engineering projects or pure physics or math. But you shouldn't choose your topic based on whether it will win awards, since these research competitions have a high degree of randomness. Projects that win a science fair with hundreds of competitors often walk away with nothing at the next. Be creative, be unique, and do something you enjoy, or you'll give up when you inevitably run into difficulties. And whether it's in a lab or your garage or after school or during 8th period, there are plenty of resources available to you, and you can always ask a teacher or lab director if you need equipment purchased or simply a second opinion.

When you embark on an independent project, let your teachers know, and ask them for advice. If you are trying to make an algorithm more efficient, talk to your computer science teacher. They may have experience in the field, or know someone knowledgeable, or at the very least, encourage and critique your idea. If you plan on submitting your work to a competition, you'll need a teacher sponsor anyway (someone to sign off on forms). And when you inevitably need a recommendation a year later, now you have someone who is familiar with your work and ambitions outside of their classroom.

7.4 COMPETING WITH YOUR PROJECT

Three major research competitions exist. Each of these competitions comes with substantial prizes, and a high place in any of them is a great achievement. However, all competitions have a certain degree of randomness. Some students will fare admirably in one competition, only to fail miserably in another with the same project.

7.4.1 *Siemens Competition*

Deadline: Late September

By Franklyn Wang (Siemens 2nd Place, 17)

> Nota Bene: The Siemens Competition ended in 2017, and will not be held in upcoming years.

The Siemens Competition in Math, Science, and Technology is a high school research competition. There are both Individual and Team categories. The Individual category is open only to seniors, whereas the Team category is available to anyone.

The submission deadline is in mid- to late-September. It requires turning in a report (which has meticulous guidelines, including citing code, double spacing, and a page limit of 18 pages), obtaining approval from the principal, and having mentors fill out forms.

In mid-October, the Semifinalists are announced. Generally speaking, if you've formatted your work correctly, you should be named Semifinalist. Semifinalists are the top 150 team projects and the top 150 individual projects. Then, the very next day, the Regional Finalists are announced. These are five projects in both the team and the individual category for each of six regions, so they number sixty projects total. The Regional Finals occur just in time for the college early application deadline.

The Regional Finalist stage comes with a $1,000 prize, as well as numerous goodies. You must make a poster and slides for your project. These are each due in late October. Then in November, each of the regional finalists will make a presentation (via Cisco WebEx) to judges from the sponsor university in their region. In order to ensure lack of bias, the judges are required to be from different universities than the mentor of the research project. The Regionals happen at different times, some in early November, some in late November. The winners of each regional advance to Nationals, and recieve an additional $2,000 on top of the $1,000 prize.

The National Finals are in the very beginning of December. Students are taken to a hotel in Washington D.C., where they enjoy five days of socializing. Judges look at the poster, the presentations, and the paper. However, the poster is not presented to the judges, as the judges view the poster in a private poster session. The prize structure was changed in 2017, so the prize given to 3rd–6th place in both categories is $25,000, the prize given to 2nd place is $50,000, and the prize given to 1st place is $100,000.

7.4.2 *Intel International Science & Engineering Fair (ISEF)*

Forms due: Early January

Reaching ISEF requires succeeding at ISEF-affiliated school and regional fairs. Forms are due in early January for TJ's science fair (or much earlier if your project involves human subjects or sensitive data). The TJ Science Fair is held in late January or early February, and all judges are TJ parents.

ISEF (and the affiliated regional and school fairs) differ from other research competitions in that you are judged relative to other projects in your category. There are approximately 20 categories, about half of which are biology-related (Computational Biology, Biochemistry, Animal Sciences, etc.). Projects can be completed individually or in a team (up to 3 people per team).

At the TJ science fair, judges do not necessarily have significant expertise in your research field, so good projects often slip through the cracks and do not win their category. Only projects that win their category are eligible for the

Fairfax County Regional science fair. **NB: the rules change every year, this was not true in 2018**.

However, if your project was awarded Siemens Competition Semifinalist or Regeneron STS Semifinalist, you are automatically eligible for the Regional science fair. (Note that you still have to participate in the TJ science fair.) Thus, the best way to ensure your project will be judged by qualified individuals at the regional science fair is to submit your project to the Siemens competition. Of course, this assumes you have finished the vast majority of your research by the September deadline.

At the Regional science fair (held in March each year), there are approximately 400 projects. For the first half of judging day, judges with expertise in your category judge all projects in your category. The judges convene, and around noon, thirty "Grand Prize Nominee" projects are called out, and the students of the other projects leave. Note that some categories may not have a Grand Prize Nominee, while other categories will have multiple. After lunch, only thirty projects remain, and a series of Grand Prize judges view the thirty remaining projects. The top 9 projects of the 30 Grand Prize Nominees move on to Intel ISEF in May. All category winners (which may or may not be Grand Prize Nominees) and Grand Prize Nominees move on to the State science fair. If you qualify for Intel ISEF (top 9), then you do not have to attend the State science fair. Note that generally, only 2–3 of the top 9 projects are team projects, and the rest are individual. From TJ, grand prize winners are generally limited to two individuals and one team. If your project wins your category or "first place" (about 75 projects), but is not in the top 9, you can still qualify for ISEF through the State science fair. However, only three to five projects out of the 200 at the State science fair qualify for ISEF.

Intel ISEF occurs in mid-May each year, and is a week-long expense-paid event held in Los Angeles, Phoenix, or Pittsburgh, depending on the year. Most of the week is spent setting up posters, meeting fellow competitors, and attending various speeches, events, and parties. Wednesday is judging day, where you will present your project to 16 judges (10 minutes per judge). Unlike previous science fairs, the judges at ISEF will only allow roughly 30 seconds for you to go over your project before interrupting your speech with questions. It is up to you to answer their questions (and follow-up questions) efficiently, and steer the conversation towards strong points you wish to highlight. There are more than sixteen 10 minute blocks throughout the day; you will have resting periods after some judging sessions.

After all judging sessions, there is one final session where no one has any judges scheduled. In this final session, judges circle back to projects of interest. In general, the more judges that visit your project during this last session, the greater your award, but this is not always true. It has varied from year to year.

Throughout science fair, there are a second set of judges called organizational judges. These judges are sent by various sponsors and decide who receives corporate cash awards. At ISEF, these cash awards are generally $1,000 to $2,000—students often win more from corporations than from their category placement. Whenever you get a judge, you should quickly discern whether they are organizational or not. Often, organizational judges have special badges. When dealing with an organizational judge, be careful to not go too technical and make sure to emphasize your research's applications. It is very advantageous to tie in your applications to the company or group they represent.

7.4.3 *Regeneron Science Talent Search (STS)*

Deadline: Mid-November

Unlike the other competitions, STS is only open to seniors. STS is the most prestigious research competition. Projects must be completed individually (working with a mentor is acceptable, and the majority do), and can be started anytime during high school.

Note that the purpose of STS is not to find the best research project, but rather to find "scientific talent". This means that STS judges a person for their scientific thinking and achievement, as well as the project's merits. Thus, the STS application is intensive, requiring numerous 300–500 word essays describing the origin and inspiration of the project, as well as your view about current scientific problems and developments. Applicants list all research and awards they have achieved during the previous four years. Additionally, a recommendation from a research mentor (if you have one), and a teacher are required. This process is comparable to, but far more rigorous than, the college application process.

Approximately 1800 projects are submitted to STS. 300 projects are awarded Semifinalist honors in early January. Semifinalist selection is based entirely on research papers. Of those, 40 projects are awarded Finalist honors roughly two weeks later, based on previous research, essays, recommendations, and other application information. If you wish to become a Finalist (minimum $25,000 in prize money), spend significant time on your essays, and have a previous research award (ISEF Finalist, Siemens Regional/National Finalist, Davidson, etc.) or extensive previous research experience. Finalists spend a week in Washington D.C. to determine the top 10 projects. There, finalists not only present their project, but also answer a series of questions regarding scientific basics from any discipline, as well as work out solutions to hypothetical scenarios. Thus, after the announcement of finalists in mid-January, many finalists spend a few weeks before March reading AP review books for biology, chemistry, and physics, to brush up on basic facts they may have forgotten. Winners are decided in early March, and are based on finalists' projects and how well they answer their questions.

In terms of the selection process, your paper is ranked within your category against all the other papers. The top 300 (Semifinalists) are determined by taking the top x percentage of papers from each category. The top 100 projects are decided in the same way. The judges then look at essays and and other submission material to whittle the top 100 down to the 40 finalists.

7.4.4 *Davidson Fellows Scholarships*

Deadline: Mid-February

This competition is open to both humanities and science research. Like STS, it involves far more than just a research project, as both recommendations and multiple essays are required. It takes a decent amount of time, so plan on working ahead of time. However, the prizes are fairly large ($10,000+ for 20 students). Note that Davidson Scholarships are also available to students in humanities fields. All projects must be individual, so most students from TJ apply their senior year, but the application is open to anyone in high school. Results come out in July. At TJ, Davidson is the least popular research competition, and only a handful of students apply each year.

In terms of the application itself, you should contact your recommenders ahead of time. The recommendation isn't really about you, but rather your project, so make sure to give them a thorough description of your project. The recommender form is online so you can look at it before giving them the information. Besides that, make sure your paper is very, very thorough. In general, Davidson prefers theoretical research so make sure to give rigorous proofs and explanations of your work.

7.4.5 *Google Science Fair*

Submission Window: September to December

Prior to 2016, Google Science Fair was a global science competition where students between the ages of 13 and 18 submitted projects online between February and May. Students could compete as teams of up to 3 or as individuals, and had to submit a summary of their work, a short video/presentation, and a research paper. One hundred Regional Finalists were announced in July. Sixteen Global Finalists were announced in August, and were invited to a ceremony in California where the 5 winners (including a grand prize winner) were announced in September. Winners were split evenly between projects from the two age categories, 13–15 and 16–18. The Grand Prize Winner received $50,000; the other winners received various smaller awards.

Google Science Fair did not occur in 2017 or 2018. A revamped website now appears at `googlesciencefair.com`, and offers little information other than the submission window: September to December 2018. The rules, format, procedures, and prizes of the new competition may be different than previous Google Science Fairs. Nevertheless, this competition may serve as a valuable opportunity for students now that the Siemens Competition has been discontinued.

8

RESEARCH VS. CAMPS

Now that you've read through many of the research opportunities outlined in the previous chapter, as well as the Olympiad camp avenues in Chapter 6, you may be wondering which path to pursue. Should you work towards a camp or conduct a research project?

This is a difficult question to answer. In an ideal world, you should do both, but as time is limited and you will have other activities (homework, sports), it is very difficult to be successful in both research and camps. Students who succeed in both research and camps waste little time and are extraordinarily motivated. In addition, they tend to pursue projects in the field of their camp.

Generally speaking, Olympiad camps provide a more surefire way of demonstrating your knowledge. If you put in the time, study the books, and do the practice problems consistently, your performance in qualifying exams will reflect your hard work. Of course, nothing is a guarantee. In every subject, an exam might focus on a particular area you neglected, or you might just be unlucky and forget a formula or a fact or make an arithmetic error. But none of these unplanned errors even begin to compare to the randomness in research competitions.

Research competitions contain a great deal of randomness. In lower levels of the science fair, parent judging is horrendous. Organizers have even said themselves that parent judging is poor. At the regional and state level, judges are slightly better, seeing through towering poster boards and unnecessary electronics, but they still make mistakes. Consider it from their perspective. A single judge will never view every project in a fair. A judge won't even view every project in a category. And how does one compare research in one field to another? When you view one project that is clearly better than another, it's easy to tell them apart, but at the upper echelons of research competitions, projects all seem similarly complex and competitors make equally bold claims. By and large, the projects that win a fair are in the top 5–10%, but they are not guaranteed to be the best.

For competitions requiring a full research paper, judging is slightly better, but still contains randomness. At least you can fully flesh out your ideas, and judges (presumably) read through your full methodology, results and conclusion. But even then, when it comes to STS, reading through the top 300 projects won't help you pick out the forty best—which is why judges rely on recommendations, essays, and past research experience.

At the end of the day, Olympiad camps are certainly more work to reach; expect a minimum of two years of work to reach any particular camp (save MOP, which is far more difficult, since students are exposed to competition math far earlier than they are to biology or chemistry or physics). But if you truly enjoy the subject, if you really have a passion for the field, the work will seem enjoyable, and the knowledge gained will benefit you greatly in subsequent years whether you make camp or not. Plus, there are always other competitions where you can win prizes and gain recognition (like the Toronto Exam for biology students or Chem 13 for chemists), and preparing for camp will certainly prepare you for these contests.

On the other hand, the majority of research projects (even winning projects) take less than a year to complete. In addition, most of the work is concentrated in the summer months, when students are free from their other commitments. But working longer or putting more effort into your project doesn't improve your odds of success. Instead, research success relies on a broad set of skills. It requires an interesting idea with broad implications, the skills and resources to complete the problem, and eloquent writing and speaking. Camps require narrower but deeper knowledge, making it nearly impossible for a student to transition from research to camps, but certainly possible to move from camps to research.

Younger students often prefer to pursue camps. Since almost no one has any significant biology, chemistry, physics, or computer science knowledge before 9th grade, freshmen start off on even footing (except competition math, of course). Starting early is key for camp success. In addition, younger students often don't have the broader skills necessary to succeed in research competitions, from scientific writing and poster presenting to basic computer science (many projects have small algorithmic parts). But by junior year, if you haven't made significant headway into your field, it will be extraordinarily difficult to qualify for a camp, so older students tend to prefer research. Nevertheless, these students' camp efforts are not for naught. Even if you never qualify for a camp, the knowledge you gain from studying greatly expands the possible research projects you have the skills to pursue.

We leave you with the following advice. If you prefer honing your knowledge in a particular field, diving far deeper than what TJ will teach you, and want to be one of the best high school students in the nation in your field, pursue a camp. However, if you would much rather apply your knowledge from coursework and extra readings, if you prefer to learn on the go and think of interesting ideas and execute them, then pursue a research project. And whenever possible, do both.

9

STANDARDIZED EXAMS

Taking standardized exams should be a fairly straightforward process. We recommend taking the SAT between second semester sophomore year and first semester junior year. Most students don't (and shouldn't) take the SAT more than twice. Take practice SAT's, set yourself a *realistic* target score, and do not retake the test if it is unlikely that you will improve by more than 30 points on your next try.

Above a certain point, your SAT score has little bearing in the college admissions process, but can be useful for National Merit Scholarship awards. You should do well on the SAT math section, provided you make no silly mistakes. SAT math covers basic topics compared to the TJ curriculum. The SAT essay is also fairly straightforward if you follow the rubric. We recommend reading the official Collegeboard suggestions online, so you know how your essay will be graded. The SAT essay format (persuasive writing) is also very similar to that taught by most English 11 teachers at the beginning of junior year.

If you are applying as a STEM major, you will most likely need to take two (2) SAT II exams. Unless you wish to attend Georgetown, no additional SAT II exams should be taken. SAT Math 2 must be one of your two exams. The math exam requires little extra preparation and should be taken sometime near the conclusion of the school year (preferably June), as you will have less coursework at this time. Much of the material overlaps with TJ Math 3 and 4 curriculum. Many schools require your second exam to be a science SAT II. There are two SAT II Biology exams, and either one should be taken near the conclusion of AP Biology. The SAT II Chemistry exam should be taken near the end of Chemistry I or AP Chemistry, since it tests a subset of either courses' curriculum. On the other hand, the Physics SAT II covers material outside the AP Physics curriculum, so you will need to study for that exam if you choose to take it. Thus, it is recommended that you take the SAT II Biology or Chemistry if you have taken AP Biology or Chemistry, respectively. You should aim to achieve an 800 on all SAT II exams you take. A lower score won't hurt you, but an 800 is more than doable with practice.

It goes without saying that you do not need any test preparation outside of taking a few practice tests during the weeks before an exam. You can find dozens of practice test books (Barron's, Princeton Review, Kaplan) at your local library. Any outside services are frivolous, useless, and expensive wastes of time.

10

RESUME-BOOSTING ACTIVITIES TO AVOID

Many students at TJ perform resume-boosting; they engage in activities solely for the purpose of inflating their achievements when applying to college. Resume-boosting includes, but is not limited to:

- Founding a non-profit
- Founding a start-up
- Paying for science fair projects (This often takes the form of research camps that cost thousands of dollars)
- Disingenuous volunteer work
- Giving a TEDx talk
- Unproductive internships
- Creating a club
- National Honor Society
- Foreign Language Honor Society (membership; officer positions have tasks)
- Exaggerating hackathon projects (presenting 24-hour work as multi-week affairs)

Of course, not every non-profit or start-up is founded for the resume-boost, however, the vast majority of non-profit organizations and start-ups founded by high school students go nowhere, and you would be better off joining a legitimate organization rather than founding your own.

Internships which do not provide you with a meaningful opportunity to grow and learn are also a form of resume-boosting. Many students take on a job simply to add an additional activity to their list (most likely between junior and senior year, when they realize they don't have enough for college applications).

We have already discussed the difficulties in founding a club in Chapter 3. Creating a useful club is not resume-boosting, but founding a club that accomplishes nothing and teaches little while sounding important on paper is certainly resume-boosting. If a club name is excessively long or sounds complicated, chances are it was founded for the resume-boost and lives on as a useless organization.

Unfortunately, resume-boosting, done thoroughly, actually works. Enough nonprofits and conference talks can get you into Harvard, nevertheless, you should not take the path of resume-boosting.

Why, if resume-boosting can get me into Harvard, should I not pursue it? Simply put, resume-boosting *only* works when you pick up news coverage (this does not mean a local paper, like the Fairfax Times, but rather a national publication or technology/science website). Once you have convinced a significant publication that your start-up/invention/non-profit is a legitimate enterprise, others will follow and fairly soon articles about you and your project will cover the first page of Google when anyone searches your name.

This is, of course, rare for a TJ student. It is extraordinarily difficult to convince a legitimate publication to run a story on a high school “wiz-kid" without connections. If successful, however, it will be your ticket to Harvard/Stanford. If you cannot convince a news outlet to run a story on your project, all your effort creating a non-profit/start-up will go to waste. At this point, colleges pretty much assume all of the activities listed above are BS unless proven otherwise. And thus, 95% of resume-boosting fails.

Resume-boosting is one reason why Olympiad camps are significant accomplishments. You cannot boost your way to a camp, you must achieve the knowledge and skill yourself. Research competitions can be muddied by projects that were paid for (usually through expensive research camps), but paid projects for the most part fail in the early stages of research competitions.

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APPLYING TO COLLEGE

Applying to college from TJ is a competitive process. Numerous students apply to Harvard, Princeton, Stanford, Yale, and especially MIT early and regular. First, we will cover non-TJ-specific terminology.

11.1 TERMINOLOGY

- *Early*: Refers to applications due November 1st (or earlier). Generally, students apply to 1 or 2 schools early. Results generally come out the week before December 15th.
- *Regular*: Refers to applications due January 1st (or around that time). If students do not gain admission to their top choice during the early application round, they apply to the rest of their schools in the regular round.
- *Early Action*: Applying to a school early action means you can apply to other schools early. Prestigious and popular early action schools include MIT and Caltech.
- *Restrictive Early Action*: You can only apply to other public universities early. Prestigious and popular REA

schools include Stanford, Harvard, Yale, and Princeton.

- *Early Decision*: You can apply to other schools early, but if you gain admission to an Early Decision school, you must attend the school. Prestigious and popular ED schools include Cornell, Duke, Columbia, and Carnegie Mellon.
- *Deferral*: An early application that is not accepted but not rejected. Deferred applications are reconsidered in the regular round.
- *Waitlist*: Students who aren't quite strong enough for regular admission are offered a spot on a waitlist. Some waitlisted students will be offered admission in May. The percentage of waitlisted students offered admission vary greatly by college, but are generally small (<10%) for elite colleges.
- *Yield Rate*: The percentage of students who, once admitted, decide to matriculate and attend that particular university. Schools usually want to have a higher yield rate, as it comes with prestige and gives them more control in filling their class (less risk of under or overfilling).

11.2 EARLY ACTION & EARLY DECISION

Applying Early Decision raises your chances of acceptance, since fewer people are willing to commit to a school in November. In addition, Early Decision schools tend to not be the top institutions, rather, they aim to lock up students who might otherwise get into a more prestigious university, thus increasing yield rates. For example, Harvard, Yale, and Princeton are Restrictive Early Action, because these schools already have high yield rates, whereas the other five Ivies all have Early Decision programs.

Some schools have extremely high deferral rates (up to 80%) for early applicants. These schools are generally prestigious institutions, such as Princeton, Harvard, and MIT. Notably, Stanford has a low deferral rate, resulting in a much higher percentage of deferred applicants accepted in the regular round (15%). Some students may choose to send a "letter of continued interest" to these colleges, however, some colleges, like MIT, have a specific "February Update Form" for you to let them know of any achievements since November. Nevertheless, due to high deferral rates, the vast majority of deferred applicants do not receive admission. Treat a deferral like a rejection, and put your best effort into your regular applications to maximize your success.

From TJ, roughly 12–16 students make MIT, about 8 make Harvard, Princeton, and Yale, and 5–8 make Stanford, although this varies from year to year. This does not mean that 41–48 students make these colleges, since the "top 5–10" students will inevitably gain admission to 2–3 of these colleges and thus be double-counted in these figures. For the early round, expect that no more than 8 will make MIT, and no more than 4 for the other colleges listed above. Please keep in mind that these figures are all based on recent data (within the last 3 years), but could easily change in the next few years. It is also worth noting that several of these students are recruited for athletics, and thus have near automatic admission.

11.3 IN-STATE VS. OUT-OF-STATE

A single university can have different acceptance rates for in-state vs. out-of-state applicants, or for its different schools. For example, the UVA acceptance rate for in-state students was 41.3%, as opposed to a 23.7% acceptance rate for out-of-state applicants. This benefits TJ students greatly; UVA admits the vast majority of students with $\geq$4.3 GPA post-junior year, along with students who have lower GPAs but significant extracurriculars.

For most universities, the school of engineering tends to have a lower acceptance rate than the college of arts and sciences, however, the difference in acceptance rates between them vary extensively from university to university. Carnegie Mellon, for example, has an extremely strong computer science program, so its school of computer science (SCS) has a 5–6% acceptance rate, less than a quarter of its other schools.

Not only do universities have vastly different acceptance rates for in-state and out-of-state students, the tuition for in-state universities can be as low as a quarter of the out-of-state tuition. This is a major reason why so many TJ students go to UVA, even though they may have been accepted to a better institution. For them, its not worth the extra $150,000 for a slightly better education.

11.4 APPLYING TO TOP UNIVERSITIES

If you wish to attend a top university (without resume-boosting), in general, you should have at least one major research or camp accomplishment. Note that you don't necessarily need to attend a camp, for example, qualifying for USAMO many times is a very significant accomplishment. Some examples of “major" research/camp accomplishments are, in no particular order of prestige or difficulty:

- STS Finalist
- ISEF Finalist
- Siemens National Finalist
- Siemens Regional Finalist ($2\times$)
- Attending RSI
- Participating in PRIMES-USA
- Davidson Fellow
- Attending MOP, USAPhO, USABO, or USNCO
- Attending USACO twice
- Qualifying for an international olympiad
- Making USAMO $2-3\times$
- Coauthor of paper published in prestigious scientific journal

This is by no means a complete list. Any particularly unique, noteworthy, or prestigious nationally recognized award—of which there are too many to count—will find its way onto this list. But those are rare; year after year, the accomplishments listed above are the ones that pop up amongst TJ students.

Even within this list, some of the accomplishments are far more difficult than others (attending an international olympiad is far more prestigious than just attending ISEF or making USAMO a few times, for example), but they all have one thing in common: any one of these accomplishments, along with decent grades, excellent essays, good recommendations, and a few smaller achievements, can get you into the college of your choice. Obviously, the less prestigious your main accomplishment, the better your essays/recommendations have to be.

In addition, the more recent your main accomplishment, the more impressive. This is partially because it is more difficult to make camps as a junior, but also because it shows growth and a positive trend. Reaching ISEF freshman year but failing to make it past the regional science fair in sophomore and junior year tells colleges your initial research success was merely a fluke. For this reason, if you have a particularly successful sophomore year, you may want to consider applying to colleges as a junior.

If you have multiple accomplishments and projects, your essays will write themselves. Just think about an interesting experience you had when solving a problem in your research, or at a research competition, or preparing for/attending a camp, and you will find that your essay will naturally highlight and show some of your research or scientific ability. (Obviously, don't do this for all your essays.) When admissions officers read about your research, and then note that you've won awards for it, they view the project as legitimate, rather than something you've made up or exaggerated. This is why it is important to submit your research to competitions, or to win awards. You generally don't write about winning a competition or award, but rather a snapshot of an experience along the way.

Some universities favor camps (MIT, for example, is known for taking campers), while others favor research (Stanford accepted 10/10 RSI Early applicants into their Class of 2022). Simply having a high GPA, a leadership position, and a single varsity sport is not enough to ensure acceptance to the most prestigious institutions, although it is certainly possible with excellent essays and a bit of luck.

On the other hand, attending an international olympiad (IMO, IChO, IPhO, IOI, IBO), is a surefire way to guarantee admission. STS Finalists are also near-guarantees for almost all colleges. And a nationally-ranked athlete (from TJ, these athletes are few and far between, and generally swimmers, tennis players, or rowers) will certainly be recruited to one or multiple prestigious institutions. However, given that you are reading this guide, you probably don't fit into that last category. A well-rounded student, however, one who succeeds as both an athlete and an olympiad camper/finalist or researcher, is perhaps even rarer.

11.4.1 *College-specific Information*

As we mentioned earlier, MIT is known for taking campers, while Stanford favors research. The vast majority of campers apply to (and are accepted by) MIT early. MIT is also known to be the most 'resume-based' college—they often overlook mediocre essays and recommendations for MOPpers and other multi-year campers. Since MIT weighs essays and recommendations less than other colleges, its admissions are generally the least 'random'—one can predict with great accuracy who will be admitted based on accomplishments alone.

Other colleges also exhibit preferences. CMU SCS is known to like cybersecurity students (CTF competitors, especially top PicoCTF finishers) and math students (USAMO qualifiers, etc.). Harvard tends to accept 'famous students', that is, students who have articles or news stories written about them. That's not to say that Harvard only accepts famous students, or MIT only accepts campers, just that if you are famous or a camper, you have a very high chance of getting into Harvard or MIT, respectively.

You may have noticed we haven't mentioned GPA, grades, or classes much in this chapter—that's because they truly don't matter, as long as you have mostly A's and A-'s. Princeton seems to be the only Ivy school that cares—most of their acceptances have very high GPAs ($\geq$4.5 end of junior year).

11.4.2 *The Main Takeaway*

The main takeaway is this: barring any rare circumstances (such as being from an extremely under-represented minority), a STEM student who has no major research or camp accomplishment will have a difficult time getting into Harvard/Stanford/MIT. Princeton, Yale, and other top-tier colleges are a bit more lenient (since there aren't that many people with major research or camp accomplishments, and most go to H/S/M), but you *must* have excellent essays and a somewhat unique experience to distinguish yourself from the horde of other TJ students applying. Again, this advice is for STEM students; those with humanities accomplishments will have a different experience, since there are a whole slew of writing/art/fine arts competitions and achievements which colleges weight differently.

Finally, it's worth noting that there is still randomness involved. Students who have fewer accomplishments than others may gain admission to more prestigious universities. Nothing is a guarantee. Rest assured, at the end of the day, the vast majority of TJ students are happy and content with the college they end up at. College admission is not an end, but rather a beginning. What matters most of all is what you do at your university, and every college has research and work opportunities.

11.5 FINAL THOUGHTS

There are infinite paths to college admission. We have only covered a few of the ways students succeed. If you intend to follow the advice in this chapter, know that at the end of the day, it is impossible to perform well in research or reach an olympiad camp if your only motivation is college. You should enjoy the field and your work. Only then will you be willing and able to put in the time and work necessary.

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FACTORS YOU CAN'T CONTROL

Inevitably, your admission or rejection to college is partially dependent on factors outside of your control. These include:

- Legacy
- Family income
- Race
- Gender
- First in family to go to college
- Residence in a state in the middle of nowhere

In addition, your GPA is dependent on your course grades, and some teachers are harder than others. You have little control over your teacher selection, but for the most part over the course of four years you will have a mix of "easy" and "hard" teachers.

It is possible to partially control your teachers through course selection. Obviously, selecting APUSH vs. Dumb HUM or Singleton Lang vs. Teamed will change your teachers. However, you have some control in other courses. For example, signing up for Multivariable calculus and AMT will nearly guarantee you Dr. Osborne for both. Selecting courses with too little interest for even a single class can guarantee you one of your alternate courses (and you do not need prerequisites to put down a course as an alternate).

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CONCLUSION

Your experiences at TJ may differ from the book. TJ policies will change over time (generally for the worse), as will Olympiad camp, research competition, and college admission procedures. Nevertheless, we leave you with the following advice:

1. Find an academic subject you love! Possible subjects include mathematics, physics, chemistry, biology, robotics, rocketry, computer science, economics, geosystems, and many more!

2. Delve deeper into the subject. Attend the respective TJHSST club (or make one, if there is no club!). Go online and read more about the subject. Sign up for free online courses or buy books or other material. *If you don't find learning about the subject interesting, you chose the wrong subject!*

3. Find other areas of interests (academic or nonacademic) and try to improve at those as well. Again, if you find yourself not enjoying something, stop doing it.

4. Sign up for a sport at TJ (that you are somewhat decent at) and strive to improve. Exercise helps with re-

lieving stress, which may become an issue (especially junior year).

5. Be respectful in class, pay attention, and stay on top of your homework (try not to procrastinate, and use a planner!). Try to participate in class as well.
6. Give back to the community in some way during your years at TJ, whether it be through club leadership or volunteer work. Disingenuous volunteer work (see resume-boosting chapter) is discouraged.
7. (Optional) Find a friend, and do some sort of research project in the academic area that you are interested in. Even though you can enter this project into a competition, the goal here is for you to learn about research in your field; in the long run, it doesn't matter whether or not you actually win the competition.
8. (Optional) Find an internship in an area you are interested in. Otherwise, the internship will be pointless in the long run. The point is for you to learn how working in your area of interest will feel like.
9. Don't fall into the resume-boosting trap! Do not apply to internships just for the sake of having an internship, do not do a research project just for the sake of having a research project, and do not do anything just for the sake of putting it on your college application! Only do things you enjoy.
10. Put effort into your college essays, and try to finish as much as you can in the summer. Have multiple people (friends, family, or teachers) read your essays and give you feedback. Rewrite your essays many times!

11. Know that college admissions results do not define you or change who you are in any way. They are a poor indicator of intelligence and ability. Most importantly, remember that it doesn't matter where you go; what matters is what you do there.

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ABOUT

If you have any questions, concerns, or suggestions, contact one of the five authors. For some sections of the book, the author or contributor is explicitly stated. If your question concerns one of these sections, contact the listed author or contributor first.

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