EARLY COLLEGE LIFE SCIENCES PATHWAYS

Opening Doors to the Jobs of the Future

2025

MassINC Policy Center

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MASSACHUSETTS
Business Alliance for Education

Acknowledgments

Many individuals and organizations deserve tremendous recognition for this team effort. We begin by expressing gratitude to the working group at the heart of this endeavor. These leaders selflessly donated their time and expertise to the project, actively participating in meetings, promptly responding to various inquiries and requests throughout the process, and carefully reviewing and commenting on drafts. We would also like to recognize the extensive support that we received from the talented team at Agncy—Augusta Meill, Charlie Hubbard, and Radhika Dhanak. This project would not have been possible without their extensive assistance with research and convening. As part of his graduate capstone project at Boston University, John Cipollini contributed invaluable research assistance as well. Special thanks to our longtime partners at MBAE, who once again played an essential role with all aspects of the project from beginning to end. Finally, we are extremely grateful to the Mabel Louise Riley Foundation, the Cabot Family Charitable Trust, and the Richard and Susan Smith Family Foundation for underwriting this research. While these leaders and organizations provided vital contributions to the project, the authors bear all responsibility for the analysis and recommendations contained in this report.

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Dear Friends:

MassINC and MBAE both work to promote economic opportunity and educational equity across the commonwealth. The remarkable growth of the life sciences industry underscores the importance of pursuing these dual objectives in tandem.

Harnessing our highly educated workforce, life sciences firms are fostering enormous prosperity for our region. These companies are also a source of immense pride. Their products improve health, reduce the costs associated with chronic diseases, and dramatically enhance quality of life for individuals battling rare illnesses. As the life sciences sector becomes a larger component of regional wealth and identity, it is crucial that all residents have the ability to gain employment in the sector and benefit from all that it has to offer.

MassINC and MBAE have long championed Early College as a transformative approach to educating students for the state's advanced industries. In 2023, we collaborated on a blueprint examining how Early College can create stronger pathways into clinical health professions. That effort revealed numerous bottlenecks in the career preparation pipeline that Early College is uniquely equipped to address. Equally important, it highlighted the difficult work required to erect strong Early College health pathways and the need for coordinated public and private leadership to build them.

Drawing on lessons from the health pathway project, this report delves deeply into life sciences careers and the unique challenges associated with preparing students for such a dynamic, ever-evolving industry. Many business, education, youth development, and workforce leaders contributed expertise and hours of their time to help us produce this blueprint. Their efforts exemplify the cross-sector relationships we must foster and sustain to prepare students for the jobs of the future.

This report is the beginning of what we hope will be a long and productive journey. Please join us as we work to refine and implement the ideas presented in the pages that follow. Together, we can ensure that all students are able to see themselves in our cutting-edge industries and fully develop their talents to achieve their career aspirations.

Sincerely,

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I. INTRODUCTION

With Massachusetts high schools enrolling smaller and far more diverse classes, the performance of the state's economy hinges on our collective effort to maximize the potential of every graduate. On this score, an exceptionally promising intervention is Early College, an evidence-based educational model that increases the rigor of high school coursework and accelerates entry and progression through postsecondary studies (see p. 7 for a full description of the initiative). Increasing numbers of low-income, first-generation college-going students are stepping up to the challenge as high schools across the state launch these programs. With enrollment rising rapidly, Early College is sure to produce many more degree-holders. But to have real impact for the economy and for residents striving to achieve in these challenging times, this strategic initiative must also provide students with solid pathways to the jobs of the future.

On paper, every Early College program is structured to make these connections. State designation guidelines require "guided academic pathways" that introduce students to a broad fields of study. These pathways should include not only sequenced courses that fulfill major requirements but also career exploration and development opportunities in related industries. In practice, however, our Early College pathways remain significantly underdeveloped in terms of both their academic offerings and the industry-focused counseling, mentoring, and career development experiences that they provide to students.

This is largely a function of the relative youth of Early College programs in Massachusetts, and of the practical difficulty involved in creating pathways that span multiple education systems and the public, private, and nonprofit sectors. But as Early College serves more students, its latent potential will increase. This should draw more resources and partners to build pathways that offer deep academic and experiential learning.

The life sciences pathway exemplifies the budding opportunity. Roughly 90 percent of life sciences jobs require postsecondary degrees.[1] Students who develop their interest in science early and incrementally build the necessary academic skills are far more successful in forging their way through the challenging college-level STEM coursework that these degrees require.[2] So far, Framingham is the only community to offer a full-fledged Early College life sciences pathway that affords students this opportunity, but such models exist in other states. More importantly, dozens of

Massachusetts high schools are offering significant industry training—including college coursework—through the Innovation Career Pathways Program. Helping more Early College high schools build robust life sciences pathways would give thousands of underserved students the chance to pursue rewarding careers in this advanced industry.

While constructing these pathways will be a complex undertaking, Massachusetts is in an enviable position to tackle its thorny challenges. Governor Healey's new Life Sciences 3.0 package gives the sector substantial public resources to staff and equip groundbreaking workforce development efforts. From strong industry groups like MassBio to innovative workforce intermediaries like BioBuilder, Massachusetts has a trove of sophisticated organizations that can braid public and private investment to create high-quality career exploration and development experiences for youth.

Massachusetts is also vaulting into a leading position in the national Early College movement. State education agencies are currently preparing a strategy to guide the next phase of expansion. In addition to establishing growth targets, this plan will include strategies to enhance program quality; these should include measurable goals for deeper career-connected learning in knowledge industries like the life sciences.

To inform the development of this critical expansion strategy, the MassINC Policy Center brought more than two dozen leaders from private industry, education, and workforce development together to prototype an Early College life sciences pathway. Drawing on conversations with these experts, this report sheds light on what erecting pathways that serve a large volume of students in an advanced field will require in practical terms. It also offers a blueprint and action plan that Early Colleges and their partners can use to start building strong life sciences pathways right away.

In service of these dual objectives, the pages that follow fully unpack the unique value proposition of Early College in the life sciences context. Section 3 maps out a model pathway that will allow students to explore their interests in the field and put them on a firmer and faster course through postsecondary studies and into the industry. With this map as a blueprint, Section 4 details actionable steps that state policymakers, private sector leaders, and local Early College programs can take to construct this model life sciences pathway.

Key Takeaways

1. Early College is demonstrably Massachusetts' most systemic and impactful effort to increase college access and success. Marrying this educational equity strategy with industry-led efforts to grow the life sciences workforce will deliver stronger results on both fronts.

2. Building robust Early College life sciences pathways is a difficult and complex undertaking that requires strong industry involvement. At present, the industry has very little awareness of the state's Early College strategy, and there has been no formal effort to engage the sector in the state's ambitious Early College initiative.

3. With the Massachusetts Early College Initiative conducting its first strategic plan and the state's Life Sciences 3.0 economic development package signed into law, the coming months will be decisive. The actions leaders take to enable the growth of Early College life sciences pathways will heavily influence the ability of Massachusetts students to participate fully in this cutting-edge industry for years to come.

Massachusetts' Early College Initiative

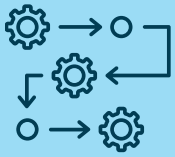
Massachusetts launched its formal Early College Initiative in 2017. At present, 57 Early College high schools throughout the commonwealth have met the criteria for state designation.[3] Students at these schools have the option to take college-level coursework at partnering institutions and earn college credits that count toward their high school diploma requirements. Students receive the college credits at no charge, and the courses are selected to transfer toward both general education and major requirements at most Massachusetts public colleges and universities.

The college courses are delivered in a variety of modes. Generally, students begin with introductory classes taught by college faculty at their high schools or online. As students progress, they take courses on the college campus. Most often, they enroll in special sections for Early College students, but some programs also offer high school students the option to take standard college courses.

In addition to tuition-free college coursework, students receive enhanced advising and tutoring services. They also gain career exploration and development experiences, including opportunities to earn industry-recognized credentials. There are no admission requirements to participate in Early College. To ensure that participants have adequate preparation, programs are increasingly working to introduce middle school students to Early College and to the steps they can take to be successful. All programs must offer guided academic pathways to receive state designation. Most offer students several choices. Health is the most common, along with liberal arts, information technology, education, and STEM.

Early College Massachusetts

A structured program of study and supports to increase college degrees, career certificates, and ultimately career success



High school students take **college classes strategically sequenced along career pathways** that count simultaneously toward high school and college completion during their regular high school day

Programs target underserved students **without admissions requirements** and at **no cost to the student**

Students receive **enhanced academic guidance and support** to ensure that they thrive in the rigorous college coursework

Students graduate from high school with significant college credits, **reducing the cost and time to degree completion**, and they graduate with the **confidence, habits, and skills** needed to be successful in college and career

Early College Life Sciences Pathway Proof Points in Massachusetts

Massachusetts Bay Community College recently created a life sciences pathway through its unique MetroWest College Planning Collaborative, an Early College consortium that includes Framingham High School, Milford High School, Waltham High School, and Framingham State University. Launched in 2022, the program has enrolled two cohorts to date. The pathway is structured to allow high school students to earn up to an associate degree in biotech from Mass Bay. Courses offered include Biotech 1, Cell Culture/Structure, and Cell and Gene Therapy. Undergraduate teaching assistants meet with the students regularly and provide tutoring. For career development, students attend industry conferences, visit employers, and participate in mock interviews. They also have internship opportunities.

While it is not a designated Early College pathway, a collaborative training program developed by Minuteman Regional Vocational Technical High School and Middlesex Community College provides students with a clear path to an associate degree in biotech. Minuteman students explore and prepare for entry-level opportunities in various life sciences careers in fields such as biomanufacturing, pharmaceutical R&D, and plant and animal sciences. In addition to graduating high school with a certificate in biomanufacturing, participants can earn up to 11 college credits through an articulation agreement with Middlesex that grants credit toward General Biology, Introduction to Chemistry, and Quality Control and Good Manufacturing Practices.

Students who matriculate to Middlesex and earn an associate degree can then transfer their credits and enter Northeastern University as third-year students. Low-income students are eligible for a full scholarship through a National Science Foundation grant program. Northeastern also works with Middlesex, the MassBioEd Foundation, and the Massachusetts Life Sciences Center to help community college students participate in paid internships at local biotech companies.

The life sciences pathway at the Dearborn STEM Academy in Boston is another standout model. All Dearborn students participate in the Innovation and Career Pathways Program (ICP), which includes a life sciences track. About 60 percent choose to continue into the school's Early College program. This allows them to complete more college courses. Dearborn's multiple pathway approach provides exposure to the industry and college without the pressure and expectations of high credit accumulation. At the same time, all students have ample opportunity to accelerate their learning and progress in postsecondary studies if they choose.

Evidence suggests that this ICP/Early College multiple pathway approach may provide a powerful blend. While Early College and ICP both increase postsecondary access and persistence, the effect size is three times larger for Early College.[4] The greater boost that the Early College pathway affords is enormous when preparing students for the life sciences, an industry in which nearly all jobs require postsecondary degrees. Massachusetts has 33 high schools with life sciences ICP pathways and several of them—including Fitchburg, Haverhill, and all five Worcester schools—already have large Early College programs. Building a robust Early College life sciences pathway will be difficult in all contexts, but these communities have an enormous head start.

II. THE VALUE PROPOSITION

Despite having the most talented workforce in the nation, all Massachusetts companies are struggling to hire skilled workers. MassINC Policy Center projections suggest that the state is on track to lose up to 200,000 prime working-age, college-educated residents before the end of this decade.[5] Early College can play a meaningful role in reversing this trend by helping more underrepresented students access and complete higher education. But the full value proposition for a strong life sciences pathway is greater and more nuanced. In addition to growing and diversifying the workforce, the pathway can not only prepare more students to succeed in diverse teams, but also leverage considerable workforce development investment in the industry to incentivize broader systems change in public education. Below, we unpack each of these arguments in turn.

1. **Early College can grow and diversify the life sciences workforce.**
   Annual workforce assessments from the industry group MassBio underscore the difficulty employers face in recruiting and retaining qualified applicants. These reports have partially attributed this challenge to a lack of understanding of the sector and of the rewarding career opportunities it offers at various levels of education and training. In recent years, there have been many efforts to increase awareness with a focus on reaching underrepresented talent. While this work appears to be paying off, a closer look at the trend lines suggests that future gains will require more systemic change.

   Growth in the industry has clearly captured the attention of students over the past decade. Between 2012 and 2022, the number of life sciences degrees granted annually by public and private institutions in Massachusetts rose by more than 50 percent. Increased life sciences degree completion among students of color accounted for two-thirds of this gain, with particularly large growth for Black and Hispanic students **(Figure 2)**.

   While this is encouraging, the gains in life sciences degree production have stalled considerably over the past few years. This is likely the result of a larger, more systemic pattern. Students of color will soon make up the majority

of high school graduates in Massachusetts, and the share of these students enrolling in college immediately after high school fell sharply during the COVID-19 pandemic. This downward trend emerged even before 2020, and it has yet to reverse.

Figure 3 reveals the full extent of the challenge: nearly half of Black and two-thirds of Hispanic graduates from Massachusetts high schools are not going on to college immediately. Controlling for a host of other factors, continuing to postsecondary studies without interruption is one of the strongest predictors of college success.[6] Delaying college makes it especially difficult to pursue advanced degrees. And an outsized share of the jobs in Massachusetts' life sciences industry require a master's degree (25 percent) or higher (20 percent).[7]

To prevent a significant decline in the state's college-educated workforce, Massachusetts must close these large racial and ethnic college-access gaps. Early College has proven that it can make a tremendous difference. Analysis by the Massachusetts Department of Elementary and Secondary Education (DESE) shows that Black and Hispanic students who participate in Early College are 15 percentage points more likely to pursue higher education than peers in a statistical comparison group. For the first few cohorts followed into year two of college, it has also had a strong impact on persistence. Combining these enrollment and persistence effects, Early College is on track to increase degree yield by approximately 75 percent.[8]

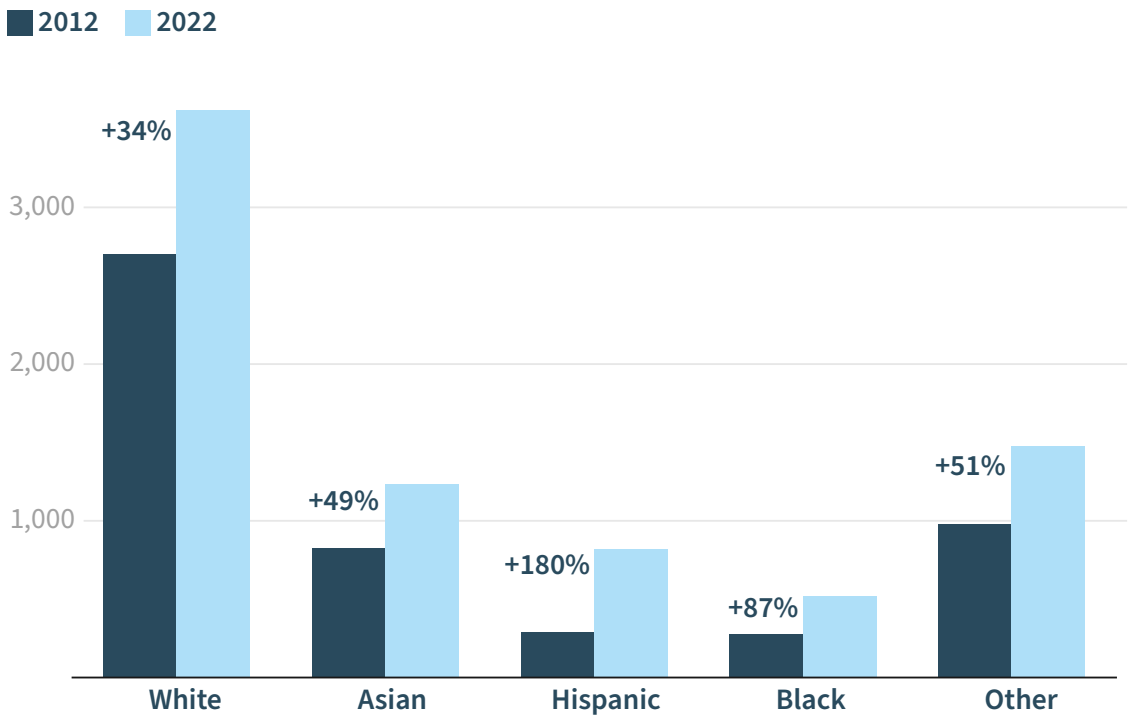
Participation in Early College has grown from 3,900 students in Fall 2021 to 8,200 in Fall 2023. This dramatic growth came during a period in which high schools were still reeling from the COVID-19 pandemic disruption and underserved students were increasingly putting college off. While Early College still serves just a small fraction (less than 3 percent) of the state's high school students, it remains on an upward growth curve. The 40 applications that are currently pending for new state designations comprise the largest batch ever received.

Estimates from MassBioED suggest that Massachusetts produces roughly 2,200 fewer life sciences degree holders annually than are needed to support the sector's expansion.[9] If enrollment continues to increase and programs successfully build robust life sciences pathways, Early College could make a significant contribution toward meeting the industry's need for more skilled workers.

Early College Life Sciences Pathways in Other States

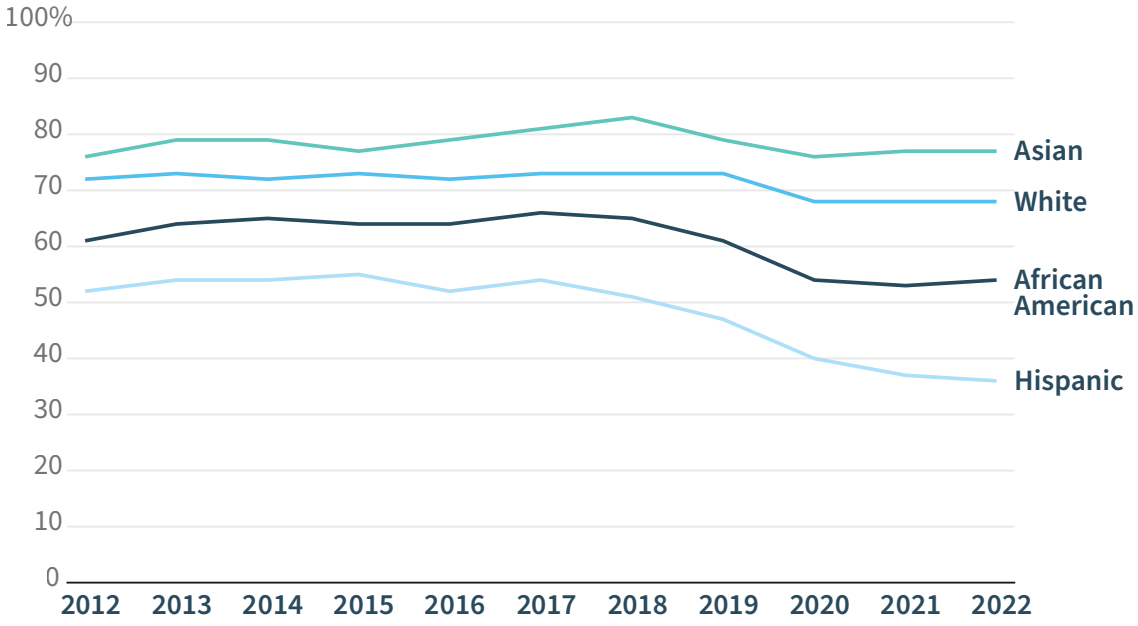
While Early College life science pathways are rare, there are several notable examples in competitor states. North Carolina's **Wake Early College of Information and Biotechnologies** partners with Wake Technical Community College to offer high school students accelerated opportunities to earn an associate of applied science degree in biotechnology. Through partnerships with businesses in the Research Triangle Park, students can also participate in work- and project-based learning to develop solutions to human health problems. Students in New Jersey's **Passaic County Technical-Vocational Schools' Biotechnology Early College** simultaneously earn their high school diploma and up to a 60-credit Associate of Science degree in biotechnology from Passaic County Community College. They also have opportunities to train and test for industry-relevant credentials, such as the Sterile Processing Technician Certification and the Certified Logistics Technician designation. Students attending Montgomery County Public Schools can join the **Montgomery College Biotechnology Pathway**, attending all courses on the community college campus during their junior and senior years as they complete an Associate of Science degree in biotechnology.

Figure 2: Number of life sciences degrees awarded by public and private institutions in Massachusetts



Source: IPEDS

Figure 3: Share of Massachusetts graduates enrolling in college immediately after high school



Source: MA Department of Elementary & Secondary Education

2. Early College can prepare workers to succeed in more diverse teams.

The benefits of diverse teams in creative R&D endeavors are well understood. But such teams function best when their members have the psychosocial skills to engage with different cultures and perspectives. In Massachusetts, high levels of segregation during the formative stages of adolescence make it difficult for many to gain these skills.[10] In this regard, Early College pathways that bring students together from diverse backgrounds would have added value for the life sciences industry.

Several recent developments are drawing renewed interest in ensuring that our secondary schools offer integrated learning environments. These developments include the 50th anniversary of the school desegregation order in Boston, the recent Supreme Court decision ending affirmative action in higher education, and the accumulation of evidence that attending schools with high concentrations of poverty seriously undermines human potential.[11]

While integration is not a clearly defined objective for the state's Early College program, it has been a primary interest for the MassINC Policy Center. It has also been a priority for Gateway City leaders, who believe that providing high school students with opportunities to access expertise and equipment that their local colleges hold will create a strong draw for all types of families. This view is in line with research, which shows that high school programs that offer rigorous learning opportunities lead to greater integration.[12] As Massachusetts develops an Early College expansion strategy, industry leaders can join with education equity and civil rights groups to press education leaders to take full advantage of the model's intrinsic ability to promote integration.

3. Early College can leverage the industry's workforce development investment to incentivize systems change in education.

Over the years, there have been various attempts at high school redesign to make instruction more relevant, while also raising standards, so that more students are prepared for the skill requirements of our knowledge industries. These efforts invariably struggle to overcome inertia and friction, leaving employers with fewer incoming workers who are prepared for the demands of the modern workplace.

> "Early College pathways foster skills to engage across diverse cultures, benefiting the life sciences industry."

While Early College is also struggling to overcome the exceptional staying power of the traditional high school model, it is gaining breakthrough momentum. By partnering with Early College innovators to transform systems and better serve students at a critical stage of college and career identity development (see box on p. 15), the life sciences industry can gain even more leverage from the sizeable investments it is making in workforce development initiatives.[13]

The Massachusetts Life Sciences Workforce Development Ecosystem

The Massachusetts life sciences sector is nurturing an impressive workforce development ecosystem. The largest funder and intermediary is the Massachusetts Life Sciences Center (MLSC). This quasi-public state agency invests nearly $20 million annually in a variety of workforce initiatives. These initiatives include the Internship Challenge program, which provides nearly $10,000 in matching funds for each college intern hired by companies in Massachusetts. To help ensure that this program draws underrepresented students, MLSC operates Project Onramp. In 2023, Project Onramp provided wraparound training and support to 163 Massachusetts college students, three-quarters of whom were from Boston (78) or a Gateway City (43).[14]

MLSC also supports high school internships for underrepresented students each year through its High School Apprenticeship Challenge. To subsidize wages, host organizations receive up to $4,000 per intern. To help prepare students for these experiences, the program also offers pre-internship outside-of-school time lab training. In FY 2023, the High School Apprenticeship Challenge served 113 students; 70 percent came from Boston (21) or a Gateway City (57).

The City of Boston is also an increasingly large funder. In February 2024, Mayor Wu made a $4.7 million investment in her administration's Life Sciences Workforce Initiative through a combination of federal ARPA funds and city resources. The initiative includes new partnerships to train over 400 residents without college degrees for life sciences careers. Together, Year Up and MassBio will serve as an intermediary that helps employers, training and education organizations, and community-based nonprofits reach city residents and prepare them for jobs in the industry.

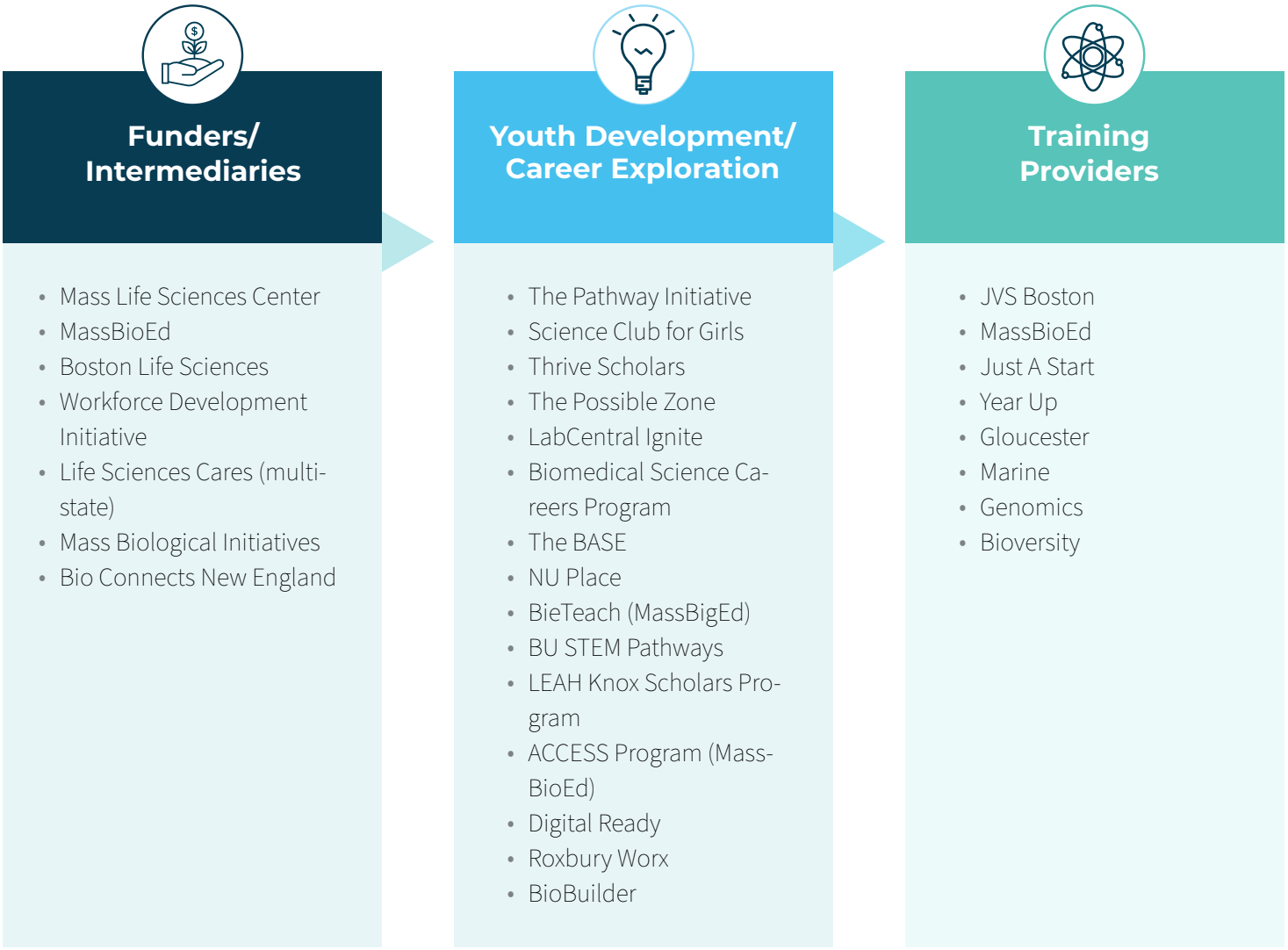
Public funding leverages significant private sector investment in the life sciences workforce. Companies provide roughly $9 million annually to Life Sciences Cares (LSC). In addition to leading Project Onramp, LSC provides direct grants to nonprofits that deliver STEM education and job training. LSC funds flow to five regions, but nonprofits in Boston receive a large share. Industry funding also supports MassBioEd. MassBio founded the nonprofit in 2001 to train educators in biotechnology and to introduce students to the basic science as well as to the college and career opportunities within the sector.

Public and private funds support a growing number of nonprofits. The oldest is Massachusetts Biological Initiatives in Worcester. Founded in 1984, the organization is generally known for its incubator and other supports for early-stage startups. But it also participates in a variety of workforce training efforts, including making challenge grants to partnerships that reach underserved populations. A new generation of nonprofits—including The Possible Zone and BioBuilder—are providing STEM enrichment and career exploration and exposure opportunities to youth. There are also various efforts to develop awareness of opportunities in the field, and positive identities for life scientists in communities of color. These include efforts led by local groups (such as Roxbury Worx), national industry groups (such as LabCentral Ignite), and higher education institutions (such as NU Place).

At the other end of the pipeline, an increasing number of organizations provide direct training and certification. Some groups (such as Gloucester Marine Genomics and Bioversity) are newer entities dedicated to the life sciences, while others (including JVS, Year Up, Just A Start) have a long track record of providing training in the life sciences and other advanced fields.

By giving high schools and public colleges and universities incentives and support structures to grow Early College life sciences pathways, Massachusetts can leverage this incredibly rich workforce development ecosystem to create greater opportunity for underserved students and strengthen its competitive position in the industry.

Figure 4: The Massachusetts Life Sciences Ecosystem at a Glance



Early College Fosters STEM Career Identities

Early College offers a particularly powerful intervention for STEM fields because it reaches underserved students at a profoundly important stage. Developmental psychologists view identity formation as the key task of adolescence. As high school students consider what they like, what they can do, and where they belong, a distinct career identity takes shape.[15]

Changes in the brain that occur in adolescence initiate this stage of development by giving students the cognitive ability to consider hypothetical scenarios and assess options for their futures for the first time. These neurological changes also make teens more adept at sensing how others perceive them, and at defining themselves as individuals in relation to others.[16]

How adolescents respond to all these inputs depends heavily on their environment, including the culture, resources, and reputation of schools, families, communities; as well as and the marginalization of groups by race, ethnicity, and gender. For low-income students and students of color, career identity development can be affected by a range of environmental factors, including attending a school with a poor reputation, lack of access to jobs, and reduced future orientation resulting from the threat of violence when living in a community with high rates of crime.

These forces exert considerable influence on students of color, especially as they intersect with the development of a racial and ethnic identity.[17] While racial and ethnic identities first appear in early childhood, the cognitive skills that youth gain in adolescence lead them to ponder how this identity will influence their fate, how they will choose to express it in various settings, and how this expression will vary relative to that of their parents, family, and peers.[18] Many adolescents of color struggle with the ubiquitous presence of racial stereotypes, which present a "social identity threat" that reduces their ability and desire to learn as well as the intention to pursue careers that require postsecondary education.[19]

Evidence indicates that teens who face these obstacles to positive career identity development are much more likely to thrive when they have structured professional opportunities.[20] This finding is consistent with career development theory, which suggests that career success is largely a function of hope and self-efficacy (i.e., an individual's beliefs about their ability to build and execute a plan). High school students who lack hope and self-efficacy often put the brakes on themselves at this critical developmental stage. This is one reason why high-achieving students of color are more likely to fall behind similarly gifted students during their teenage years.[21]

Whether students disengage or build resilience during this challenging developmental period may depend heavily on the signals that they receive from teachers. Educators often send the wrong message by lowering their expectations for disadvantaged high school students.[22] In part, this is the result of experience telling them that these students will not get the opportunities needed to succeed in the most challenging courses, in which access to experienced teachers, tutors, summer enrichment, and assistance from parents becomes all the more important.[23] And underperforming at this critical stage of development can exact heavy costs. For instance, research shows that students who score low on AP exams are significantly less likely to pursue STEM majors in college.[24]

As Massachusetts develops its Early College strategic plan, it must tap those with expertise in college and career identity development (and STEM identity development in particular) to ensure that it puts forward goals and design guidelines that are consistent with the deep research and knowledge base in this area.

III. A MODEL EARLY COLLEGE LIFE SCIENCES PATHWAY

Harnessing the full power of an Early College life sciences pathway will require a design that layers and sequences learning opportunities from middle school all the way up to the high school-college transition. This section begins with a discussion of high-level design principles. We then present an illustrative map that organizes the delivery of enhanced advising and student support, college-level coursework, and career exploration and development along the pathway. Throughout the section, we utilize sidebars to call attention to structural challenges that must be addressed through design, policy change, or a combination of the two.

Four Design Principles

1. **Serve all students and provide them with multiple on-ramps and off-ramps.** The Early College life sciences pathway provides an ideal opportunity to design a high school-to-postsecondary education path that can serve a wide spectrum of students equally well. This pathway can challenge the most advanced students with high-level science, statistics, and programming courses. For those who struggle with rote academic instruction, the pathway can provide interdisciplinary courses as well as ample opportunity for practical and contextualized learning.

   To meet the needs of different learners, the design should vary not only in its content but also in its objectives. For advanced students, the goal may be significant credit accumulation to accelerate progress toward a four-year degree. Successfully completing a college-level lab science course could be a strong outcome for the more typical student, who is more than capable but will benefit by building confidence and progressing through the required coursework at a measured pace. For those who learn best on the job, the pathway can aim to provide the basic academic foundation for entry-level work and industry-recognized credentials, along with skills to navigate college if they require further postsecondary studies as they progress in their careers. The multiple-on-and-off-ramp approach can also provide more stability and security for students who must slow or delay their postsecondary studies due to unforeseen life circumstances.

   More fundamentally, this flexible design recognizes that Early College serves many students who are at the postsecondary success margin. While a large number will never complete college degrees, they can all build tangible skills with labor-market value through their participation in the pathway.

2. **Cohort students.** Whether it is furnishing unique summer experiences or connecting students with industry

leaders, mentors, and advisors, all Early College pathways can benefit from some level of coordination to create economies of scale across programs. However, this is particularly true for the life sciences. Except at a standalone Early College life sciences high school, the number of students opting for this pathway from each individual school is likely to remain relatively small. Coordinating across programs will provide efficiencies.

The advantages of bringing students together across high schools are even larger when you consider the benefits for student motivation, identity, and mutual support. Numerous studies show that cohort-based STEM interventions allow students to provide one another with peer support. Cohorting also expands opportunities for building collaboration skills, increases feelings of belonging, and promotes the development of a positive scientific college and career identity.[25]

By creating sections of college courses exclusively for students from a partner high school, Early College already uses a cohort model of sorts. Life sciences pathways can build on this by assembling strong cohorts made up of students from multiple Early College high schools.

3. **Build structures to support cross-sector alignment on skill requirements and to enable dynamic responses to industrial change.** The life sciences sector exemplifies the interdisciplinary skills that jobs in the state's advanced industries require. Students need lab skills and other subject-area knowledge, but they also must have the ability to analyze complex datasets using sophisticated statistical techniques. Even more fundamentally, they must be able to work collaboratively, think critically, and solve problems in an entrepreneurial fashion. The conventional academic pathway to a life science degree consists of old building blocks (e.g., Biology 101, 201, etc.; Chemistry 101, 201, etc.); it is not constructed to efficiently provide students with the skills and dispositions they need to succeed in this field.

   The initial development of an Early College life science pathway provides educators and industry leaders with a unique opportunity to clearly articulate what students need, then deliver learning opportunities that help them develop these competencies. (Our model pathway enumerates these skills and dispositions at a high level, but a true design will catalog them in finer detail and show how each course and learning experience contributes to their development.)

   An effective pathway will also include structures that facilitate continuous exchange around learning objectives to ensure that everything from curriculum and professional development to equipment purchases can respond dynamically to change in this rapidly evolving field. This component of the design is critical to overcoming the coordination challenges between high schools (which plan several months in advance) and colleges (which plan several years in advance). Formal coordinating structures can also help provide sustainability, insulating high schools from the considerable leadership churn that they often experience.

4. **Leverage vocational schools and industry training partners**. Efficient utilization of spaces equipped with industry-standard technology is key to building pathways that cost-effectively serve large numbers of students. In addition to improving facilities at public colleges and universities, Massachusetts continues to invest in state-of-the-art equipment at its vocational schools and has a growing number of training facilities designed to prepare adults for life sciences careers. There are numerous ways that Early College designs can take advantage of this infrastructure to build strong life sciences pathways with multiple on- and off-ramps.

   For instance, there are often times when the high school and college schedules do not align due to differing vacation weeks and shorter terms in higher education. During these periods, students could undertake experiential learning projects at a training facility. Pathway designs could also provide high school students with the option to complete their studies at a vocational school or training partner, where more flexible schedules allow for co-ops and other time-intensive training modules.

A Model Life Science Pathway Design

Conversations with Early College, youth development, workforce, and industry leaders led us to the model presented in **Figure 5.**[26] This map gives definition to the life sciences pathway by charting key milestones and showing how they align with grade spans, and with the core components of the model: enhanced advising and student support services, college course offerings, career exploration and development experiences, and credentialing opportunities.

Figure 5: An Illustrative Early College Life Sciences Pathway

	MIDDLE SCHOOL	HIGH SCHOOL		
	GRADES 6-8	GRADES 9-10	GRADE 11	GRADE 12
MILESTONES	Early College Selection	Life Sciences Pathway Selection	Major/Credential Selection	
COURSEWORK (college level courses in bold)		Biology Chemistry Algebra II **Intro to Life Sciences**	**Biology 101** **Biotech 101** **Bioethics** **Biomanufacturing** **Cell and Gene Therapy** **Cell Culture** **Microbiology** **English Composition** 1 (with life sciences theme)	
CAREER DEVELOPMENT	Broad exposure to field (from health and biotech to ecology and food science) through: Visiting speakers STEM expos Visits to colleges and industry work spaces Clubs and extracurricular activities	College visits Employer visits Hackathons	Industry conferences Mock-interviews Job shadowing Peer mentors	Conferences Project-based learning/simulations/ capstones Internships Co-ops Industry mentors
CREDENTIALS		BSCI micro credentials	BSCI micro credentials	BACE exam GMP certification

Enhanced Advising and Student Support

Enhanced advising and student support services are central to the Early College design, but they are especially important with an ambitious life sciences pathway that introduces students to a relatively obscure industry and encourages them to think years into the future (at a developmental stage where this is still difficult).

Ideally, the advising process begins when programs reach down into middle schools to provide students with Early College awareness and STEM career exploration activities. These efforts should also include substantial effort to ensure that parents and caregivers have greater awareness of Early College generally and of the life sciences pathway in particular. Families should have a chance to learn more about the industry, its career preparation demands and expectations, and the initial steps that students can take to position themselves for success as they complete middle school and enter an Early College high school.

As students move through high school, the life sciences pathway must tailor advising and support to the life sciences industry. Students should have frequent opportunities to meet and hear from professionals at various levels in the field. Programs should also offer one-on-one mentoring beginning in ninth grade with near-peers and progressing to college and/or industry mentors in the upper grades.

Tutoring is another key component of the pathway design. By using co-teaching models that pair high school faculty with college professors for key courses, programs can give students ready access to additional help as needed. Programs can also draw on the resources of their university partners by utilizing both graduate and undergraduate tutors with work-study funding.

College-Level Coursework

Life sciences companies hire graduates from several fields. Biology is the most common, followed by chemistry, chemical engineering, and more specialized degree programs such as biostatistics.[27] While the vast majority of jobs in the industry require at least a four-year degree, companies do hire some graduates who have associate degrees and/or industry-recognized credentials.

The courses that Early College pathways offer will have a strong influence on the academic direction and momentum that students build, especially for those wishing to pursue two- to four-year transfer pathways or direct enrollment in four-year institutions. Success in these lanes will require preparation that gives students a clear direction and the ability to strategically take on the most challenging courses.[28]

To help students find and navigate their preferred path, Early Colleges can begin with a 3-credit college-level Introduction to Biotechnology course that offers opportunities to learn about gene-editing techniques, gene therapies, and biomanufacturing, as well as about the various occupations associated with these products and technologies. Students can then move on to their first 4-credit lab course. This college-level class should build on high school coursework that students have already completed, preferably in biology.

Students interested in accelerating their progress toward a four-year degree should have the option to take several more lab courses, as these classes make up the vast majority of the coursework required for biology and chemistry majors. Programs that partner with community colleges should select courses from the A2B mapped pathway to ensure that these credits will transfer toward major requirements at public four-year colleges in Massachusetts. (As illustrated in **Figure 6**, existing articulation agreements allow students taking classes at North Shore Community College to transfer up to 35 credits toward a Bachelor Science in biology at Salem State. All community colleges have a similar A2B path for biology and chemistry.)

Some Early College students will be well-served by a pathway that accelerates progression toward a two-year biotech degree. This will allow them to enter the workforce and gain on the job experience. In addition to their earnings, they may also be able to take advantage of valuable employer-sponsored tuition assistance if they pursue a four-year degree part-time. A student seeking an Associate in Science Degree in Biotechnology from Mass Bay Community College will need to complete many of the same foundational courses as those pursuing a Bachelor of Science in biology. However, the associate in biotechnology also requires more specialized 200-level courses, such as Cell Culture and Gene Expression. While currently there is no guarantee that the later courses will transfer, they may meet elective requirements for biology and other four-year majors.

With their higher education partners, Early College life sciences pathway designers can also contextualize general education course requirements. A course such as Writing for Biotechnology could satisfy an English Composition I requirement while also readying students for demands that are unique to the life sciences workplace.

Figure 6: Selected Community College Biology and Biotechnology Pathways

North Shore Salem State A2B Biology Pathway

Course		Credits
BIO 105	General Biology 1 w lab	4
BIO 106	General Biology 2 w lab	4
CHE 103	General Chemistry 1 w lab	4
CHE 104	General Chemistry 2 w lab	4
MAT 152	Precalculus 2	3
CHE 201	Organic Chemistry 1 w lab	4
CHE 202	Organic Chemistry 2 w lab	4
PHY 101	Introductory Physics 1 w lab	4
PHY 102	Introductory Physics 2 w lab	4

MassBay Biotechnology (AS)

Course		Credits
BI 110	Principles Of Biology I W/ Lab	4
BI 120	Principles Of Biology Ii W/ Lab	4
BI 210	Molecular Biology W/ Lab	4
BI 220	Immunology W/ Lab	4
BT 101	Introduction To Biotechnology	3
BT210	Cell Culture	3
BT215	Gene Expression Laboratory Course	3
BT240	Research Internships	4
CH 110	Principles Of Chemistry I W/ Lab	4
CH 120	Principles Of Chemistry Ii W/ Lab	4
CH 201	Organic Chemistry I W/ Lab	4
CH 210	Biochemistry I W/ Lab	4
MA 102	College Algebra	3

Figure 7: Selected Four-Year College Biology and Biotechnology Programs

UMass Lowell Biology/Biotechnology Major

Course		Credits
BIOL.1110	Principles of Biology I w lab	4
BIOL.1120	Principles of Biology II wlab	4
BIOL.1160	Freshmen Seminar	1
BIOL.2330L	Experimental Methods in Biology	2
BIOL.2350	Genetics (CTPS)	4
BIOL.2xxx	Cell and Tissue Elective	3
BIOL.2XXX	Organisms, Evolution and Environment Elective	3
BIOL.3/4XXX	Biotechnology Elective	3
BIOL.3/4XXX	Biotechnology Elective	3
BIOL.3/4XXX	Biotechnology Elective w/Lab	4
BIOL.3/4XXX	Biology Elective	3
BIOL.3/4XXX	Biology Elective w/Lab	4
BIOL.4190	Biochemistry	3
BIOL.4210L	Biochemistry Techniques	2
BIOL.4510	Senior Seminar in Biology	2
CHEM.1210	Chemistry I (SCL) w lab	4
CHEM.1220	Chemistry II (SCL) w lab	4
CHEM.2210	Organic Chemistry I w lab	4
CHEM.2230	Organic Chemistry IIB w lab	4
MATH.1380	Calculus for Life Sciences I	4
MATH.2830	Statistics (MATH)	3
PHYS.1030	General Physics	(STEM) w lab	4
PHYS.1040	General Physics II w lab	4

Worcester State Biotechnology Major (BS)

Course		Credits
BI-141	Intro to Cellular and Molecular Biology	4
BI-203	Genetics	4
BI-204	Microbiology	4
BI-205	Research Techniques and Experimental Design	2
BT-101	Introduction to Forensic Sciences	4
BT-240	Research Experience for Undergraduates	1 to 6
BT-350	Genomics	4
BT-360	Introduction to Bioprocessing	4
BT-375	Tissue Culture	4
BT-376	Biotechnology	4
BT-378	Bioinformatics	4
BT-408	Directed Study: Biotechnology	3
BT -410	Biotechnology Seminar	1 to 4
BT-440	Advanced Research Experience	1 to 6
BT-450	Internship in Biotechnology	3 to 6
CH-120	General Chemistry I	4
CH-121	General Chemistry II	4
CH-210	Chemical Analysis: an Introduction to Modern Methods	5

Career Exploration and Development

As with all Early College programs, career exploration and development is a core component of this pathway. These experiences give real-world exposure to career options, contextualize learning to make coursework more relevant, and help inform college major selections.

This process begins in middle school with STEM enrichment programs that provide broad exposure to the life sciences. Students must then have career exploration opportunities that include visits to both university labs and industry facilities. From here, the progression should include visits to local companies, job shadowing, and mock interviewing. Our region is fortunate to host numerous industry conferences that students can attend. This pathway is uniquely situated to offer paid internships with financial support available from the Massachusetts Life Sciences Center. Early College partnerships can certainly help cultivate more of these opportunities, but significant growth will be challenging given the difficulty many companies face in bringing youth under age 18 into their facilities.

Early Colleges can provide internship opportunities to students at the end of their senior year. Many of these students will have turned 18 and will only have two high school course requirements left to meet, leaving considerable time in their schedules for paid internships. Combined with classroom support and instruction, a structured internship could also provide college course credits. This opportunity would provide a major draw and a strong incentive to engage in the program.

While providing internships to all students will not be possible, Early College life sciences pathways can also create simulated experiential learning opportunities by partnering with the growing number of workforce organizations that have expertise as well as specialized facilities and equipment. Working through these industry partners, Early College life sciences pathways may also find ways to provide co-op experiences for those who wish to transition directly to full-time employment upon graduation.

Credentials

While Early College life sciences pathways are designed primarily to set students up for success in higher education, some students may wish to earn credentials as a way to burnish their qualifications, gain professional experience, and increase their earning power. Credentials can also help high school students gain self-efficacy and foster career identity development. Industry-recognized credentials can contribute to academic momentum if colleges grant them for prior learning or in combination with some other learning experience.

While pathway designers must be careful not to overburden students who are also taking college classes, they can provide opportunities to earn these credentials during the summer or break periods when colleges are not in session. Common credentials for the industry include the Biotechnology Aptitude and Competency Exam (BACE) credential from Biotility and the stackable micro-credentials awarded by the Bioscience Core Skills Institute (BSCI). For biomanufacturing and medical devices, there are certifications in Good Manufacturing Practices (GMP) and for sterile processing technicians. Several Massachusetts organizations—including BioBuilder, Digital Ready, and MassBioEd—have experience preparing students for these exams.

The Top Five Obstacles to Overcome

Building Early College pathways is difficult work, and we must be clear-eyed about the challenges. Through conversations with educators as well as with youth development, workforce, and industry leaders, we surfaced many potential obstacles that the pathway design must work to overcome. Here are the top five:

1. **Fitting college lab courses into the high school schedule.** Scheduling is a challenge for all Early College programs that operate within a comprehensive high school, but the prevalence of four-credit lab courses makes scheduling even more difficult for life sciences pathways. In addition to requiring access to specialized classrooms, student schedules must accommodate several hours of additional time for weekly lab sections. These require additional trips to the college campus, which can be costly for schools as well as time-consuming for students.

2. **Inadequate reimbursement rates for lab courses.** Massachusetts provides institutions with $200 per credit for Early College courses. While UMass and state universities have higher cost structures, they receive the same reimbursement as community colleges. And all institutions receive the same reimbursement regardless of the course offered. This makes it financially challenging to provide the numerous lab courses that students need to progress in life sciences degree programs. Limited funding for higher education partners also makes it more difficult for these colleges and universities to provide relevant counseling and tutoring services. With declining enrollment and tight budgets, many of these institutions are struggling to meet the needs of their fully matriculated students.

3. **Hiring instructors with an understanding of changing technology and industry practices.** Massachusetts high schools have great difficulty hiring science teachers. And even highly sought-after science teachers have difficulty keeping current with the needs and practices of the rapidly changing life sciences industry. Colleges and universities also face hiring challenges. With Early College enrollment growing alongside the enrollment of traditional college students, it is becoming increasingly harder to find instructors to teach Early College courses, particularly in advanced technology fields.

4. **Meeting prerequisites and transferring credits.** College-level applied life sciences classes often have several prerequisites, which makes it harder to offer high school students pathways that begin with applied learning experiences. And as more programs create applied and interdisciplinary learning courses for Early College students, it will become more challenging to ensure that students can receive credit toward degree programs wherever they choose to continue their studies after high school.

5. **Contradictory incentives from the state accountability system.** Under the state's accountability system, administrators are heavily incentivized to focus their attention on students who are struggling the most. Constructing a high-functioning Early College program requires enormous effort and significant financial resources, but superintendents and principals see little benefit in their state accountability ratings if they are successful. In this sense, leaders in urban districts that face considerable pressure to improve performance are penalized by the state for creating high-performing Early College programs.

IV. BUILDING TO THE BLUEPRINT: AN ACTION PLAN

While Massachusetts currently has only one Early College program that offers a life sciences pathway, this presents an opening to come together and build for scale from the start. This is a timely moment for such an undertaking, with state Early College leaders developing frameworks to guide the next stage of expansion and workforce leaders looking for opportunities to collaborate with industry partners to deploy new resources from the Life Sciences 3.0 package. To take full advantage of these openings, we offer recommendations for state policymakers, Early College partnerships, and business leaders in the life sciences industry.

Recommendations for State Policymakers

- **Contract with an intermediary to help programs co-develop the life sciences pathway.** There are many organizations with experience developing career-connected learning in Early College and similar settings. These consultancies can help educators co-create curriculum, professional development, advising and other support services, and career development and experiential learning opportunities for the life sciences pathway. Bringing on an established intermediary to help Early College partnerships develop this pathway will encourage others to take the leap, and the group effort will make the development process stronger and more efficient. This approach should also uncover opportunities to operate components of the pathway collaboratively to gain economies of scale.

- **Leverage workforce development funds to help Early College partnerships hire regional industry liaisons.** Community colleges have long relied on industry liaisons to help them form partnerships between their academic departments and regional employers. If Early College life sciences pathways gain sufficient scale, a dedicated industry liaison could provide a valuable contribution, brokering exchange with industry on curriculum and pedagogy as well as working with local companies to develop internships, co-ops, and career exploration opportunities. By ensuring that Early College life sciences pathways provide robust experiences aligned to the industry's current needs, state workforce development funds could generate considerable return on investment.

- **Increase the state's per-credit reimbursement for Early College lab science courses.** State course reimbursements are the primary source of funding to make higher education available to Early College students at no cost. Currently, Massachusetts provides $200 per credit. Community colleges typically charge around $260 per credit for lab courses, and the costs are far higher for state colleges and universities. As long as course reimbursements are significantly below the actual costs to deliver instruction, public colleges and universities will have a strong financial disincentive to create programs that open the doors to advanced industries. Increasing the reimbursement for lab courses to facilitate a strategy designed explicitly to increase STEM completion is almost certainly a cost-effective investment, as research shows that the return on state higher education spending is far higher when students complete STEM majors.[29]

- **Incentivize college and career success with changes to state accountability.** A DESE task force is currently reviewing options to strengthen high school accountability measures. Improving and increasing the weight given to college and career measures in the state's school performance formula should be at the very top of the list. Massachusetts trails leading states that have made efforts to ensure that their accountability metrics give high schools meaningful incentives to increase post-secondary enrollment and persistence.[30] Building Early College pathways that connect students to the jobs of the future is a massive undertaking. Educators that deliver demonstrable results should see their accomplishments reflected in state accountability reports.

- **Incentivize integration with capital funds.** The Massachusetts School Building Authority (MSBA) has very limited resources relative to today's needs. This makes it difficult for many communities to build high schools with state-of-the-art lab spaces. To the extent that Massachusetts creates these advanced learning environments at the high-school level, priority should go to schools with designs that both encourage and facilitate socioeconomic integration. High schools with Early College life sciences pathways can excel in this regard. While historically the MSBA did provide additional resources to magnet schools that draw a diverse student population, it has not made funding available for this purpose for nearly two decades.

Recommendations for Early College Partnerships

- **Change the master schedule to allow for Early College lab courses.** High schools that offer Early College must be fully committed to the students that rise to the challenge. This means refining the master schedule so that students can take a number of courses on the college campus, including longer lab sections.

- **Train and empower teacher-leaders.** STEM educator roles are among the most difficult high school positions to staff. The life sciences pathway can help, as many educators are drawn to Early College because of its transformative potential. Contributing to a strong life sciences pathway that positions students to succeed in an advanced field can be a highly rewarding professional experience. Schools can help ensure that teachers who support this pathway have numerous professional development opportunities to stay on top of the latest practices in the life sciences industry. They should also formally recognize and compensate teacher-leaders who devote additional time to building and managing these pathways. To ensure that learning opportunities respond dynamically to the changing needs of industry, partnerships must plan ahead by providing stipends to teacher-leaders and giving them the release time they need to innovate and train with peers from across the state.

- **Recruit graduates to serve as mentors and co-teachers.** With numerous programs preparing under-represented students for careers in the life sciences industry, there is an increasing number of graduates available to partner with Early College programs to serve as both mentors and co-teachers. Early College partnerships should strive to connect with these successful graduates and provide them with rewarding opportunities to give back to their communities.

- **Perform strong qualitative evaluation.** Students will build progressively toward long-term outcomes as they advance along the pathway. While course completions provide one intermediate performance measure, programs will also need qualitative data to tailor the multiple-on-and-off-ramp approach to students with various interests and needs as well as to gauge near-term efficacy with each subpopulation. This means generating valid and reliable measures of key constructs, such as a student's scientific identity, perceived family support for science-oriented college and career plans, and self-efficacy in STEM coursework. Surveys with these scales should be administered at regular intervals as students proceed through the pathway to develop a deeper understanding of the impact of various courses and experiences.

Recommendations for Business Leaders

- **Launch a challenge fund.** The most ambitious Early College programs in Massachusetts have piloted approaches with transformational potential with help from private philanthropy. However, foundation resources are limited and lack the visibility that corporate philanthropy can provide. The Massachusetts life sciences sector could fuel the development of robust Early College pathways across the state with relatively modest multiyear grants to high schools with the ambition to demonstrate the power of this approach.

> "Early College life sciences pathways offer a timely opportunity to scale innovative education models through collaboration between policymakers, educators, and industry leaders."

- **Offer a teacher fellowship program for Early College educators.** Through initiatives such as the Siemens STEM Institute, industry has long made efforts to provide high school teachers with high-quality professional development and training on cutting-edge technologies. Leading Early College courses is a challenging assignment, particularly in a field like the life sciences. Industry fellowships for high school teachers could deliver real value, providing prestigious recognition to faculty who step up to do this work and giving them the best and most up-to-date training possible.

- **Launch a community of practice around internships and other work-based learning experiences for Early College students.** Life sciences companies have donated significant funds to community-based organizations working to reach populations that are underrepresented in the industry. These companies can take this work a step further by helping Early College partnerships develop templates, guides, and resources to establish a spectrum of work-based learning experiences for students in Early College life sciences pathways. These can range from structured career days, where students visit companies and gain exposure to the different departments in a company; to year-round internship programs, where students are paired with mentors. Industry-led collaboration will be particularly valuable as Early College programs devise strategies to harness their scale through remote learning, residential summer experiences, and other creative strategies to collectively serve life sciences students from across the state at scale.

- **Engage Early College leaders as allies in the effort to build a diverse life sciences workforce for the future.** Throughout the state, Early College leaders have demonstrated exceptional commitment to creative problem-solving and cross-sector collaboration to meet the needs of underserved students. The intentional focus of Early College programs on recruiting and supporting students who are traditionally underrepresented in high-growth fields aligns closely with the diversity, equity, and inclusion goals established by many business leaders in the life sciences industry. As life sciences companies and industry groups seek policy solutions to their workforce challenges, they will find powerful partners and champions in this growing network of Early College providers.

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About MassINC

MassINC is a nonpartisan, non-profit civic organization working to make Massachusetts a place of civic vitality and inclusive economic opportunity. We believe public policy should be informed by data, evidence, and accurate information and that policy makers should be transparent and accountable to the public. We do our work across three independent divisions—the MassINC Policy Center, our civic news organization CommonWealth Beacon, and our subsidiary company, The MassINC Polling Group.

About the MassINC Policy Center

The MassINC Policy Center generates research to frame pressing issues, identify actionable solutions, and monitor progress. The Center favors a collaborative approach, engaging with state and local officials and civic leaders to surface problems and actionable strategies to address them. We strive to produce timely and accurate information that leaders can rely on when tasked with making difficult choices.

About MBAE

The Massachusetts Business Alliance for Education (MBAE) and the employers we represent believe that an excellent public education system is the essential foundation of a sound and equitable economy. We promote and support continuous improvement in our schools and innovation that is needed to ensure that EVERY student receives a high-quality education that prepares them for success in college, career and citizenship.

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