assembly bio

2022 Annual Report

> I am incredibly proud of our exceptional team, their steadfast commitment and the novel antiviral pipeline we have advanced to further our ultimate goal of improving patients' lives.

To our stockholders:

2022 was a year of important progress for Assembly Bio. We took significant steps forward in pursuit of our ambitious mission to change the path of chronic viral diseases and improve the lives of patients around the world.

The past year was also not without its challenges. Operating in a difficult biotech environment, we made tough, but necessary, decisions to focus and prioritize our clinical development and research efforts through an organizational restructuring. Amid a period of volatility and change, Assembly Bio responded with agility, resilience and purpose, relying on our unwavering dedication to the science that informs our strategic decision-making and guides our execution.

Improving lives through innovative viral therapeutics

As a scientific leader in viral therapeutics, Assembly Bio is committed to delivering life-changing therapies for people struggling with chronic hepatitis B virus (HBV), hepatitis delta virus (HDV) and herpesvirus infections. In 2022, we accelerated our discovery research programs and advanced our clinical pipeline of next-generation HBV core inhibitors. As a result, we enter 2023 well-positioned to reach our upcoming milestones and deliver value for patients and stockholders.

Advancing research programs with the greatest promise

Leveraging our team's proven expertise in virologic drug development, we made tangible progress in 2022 to expand our discovery pipeline through the introduction of four new research programs, all with clinically validated drug targets. This includes the introduction of two novel small molecule approaches with potential activity against both HBV and HDV. Beyond viral hepatitis, we are also excited about our two new

programs targeting herpesviruses, including our first development candidate outside of HBV, ABI-5366 (5366), a long-acting helicase inhibitor aimed at addressing the significant unmet need in high-recurrence genital herpes caused by herpes simplex virus type 2 (HSV-2). We expect to advance 5366 into the clinic in the first half of 2024 and to nominate a second development candidate from an additional new program later this year.

Progressing HBV clinical development

In 2022, we also made progress in our HBV core inhibitor clinical pipeline. Our drug development efforts for HBV are taking place against the backdrop of a disease in urgent need of a cure. There are an estimated 296 million cases of chronic HBV globally, contributing to an estimated 820,000 deaths each year.

Mindful of this critical patient need, we have made a series of data-driven decisions around our core inhibitor pipeline candidates that we believe will help advance the field closer to finite and curative therapies.

In the first half of 2022, we completed enrollment in two triple combination studies for our first-generation investigational core inhibitor, vebicorvir (VBR). While interim data from these studies showed that VBR continues to be a strong antiviral with a favorable safety profile, they also showed that VBR is not likely to achieve finite therapy or cure. Based on this evidence, we decided in mid-2022 to discontinue development of VBR to prioritize our discovery research pipeline and next-generation core inhibitors.

ABI-H3733 (3733) and ABI-4334 (4334) are Assembly Bio's highly potent next-generation core inhibitors designed specifically for greater potency than VBR against the formation of cccDNA, the second mechanism of action of core inhibitors. Last year, we initiated a Phase 1b trial for 3733 and a Phase 1a study for 4334, announcing initial data from both studies in December. Subsequently, based on clinical and nonclinical data through mid-March 2023, including results from the ongoing Phase 1 studies of both candidates and a chronic toxicology observation for 3733, we decided to pause 3733 and prioritize 4334 given its greater potency and encouraging clinical profile. Looking ahead, we plan to report clinical data from the final 200 mg multiple-dose Phase 1a cohort for 4334 by the end of April.

Fulfilling our commitment to operational excellence

With our refocused research and development efforts centered on our most promising compounds, we strongly believe in our ability to build on our progress to-date and position Assembly Bio for long-term growth. As efficient stewards of our financial resources, we have a cash runway that is projected to fund our operations into mid-2024.

Undoubtedly, 2022 was a year of progress and change for Assembly Bio — and for me as well. Following the retirement of John G. McHutchison, A.O., M.D., as chief executive officer at the end of the year, I am honored to now lead our team forward as CEO and join our Board of Directors. I am incredibly proud of our exceptional team, their steadfast commitment and the novel antiviral pipeline we have advanced to further our ultimate goal of improving patients' lives. I believe our future holds much promise for the important work we do.

I look forward to reporting our continued pipeline progress to patients, the scientific and medical community and our dedicated stockholders. On behalf of all of us at Assembly Bio, thank you for your continued support.

Sincerely,

Jason A. Okazaki
Chief Executive Officer and President

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, DC 20549

FORM 10-K

☒ **ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**
For the fiscal year ended December 31, 2022
or
☐ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**
For the Transition Period from _____ to _____

Commission File Number**: 001-35005**

ASSEMBLY BIOSCIENCES, INC.

(Exact name of registrant specified in its charter)

Delaware	**20-8729264**
(State or Other Jurisdiction of Incorporation or Organization)	(I.R.S. Employer Identification No.)

331 Oyster Point Blvd., Fourth Floor
South San Francisco, California 94080
(Address of Principal Executive Offices)

Registrant's telephone number, including area code: **(833) 509-4583**

Securities Registered Pursuant to Section 12(b) of the Exchange Act:

Title of Each Class	Trading Symbol(s)	Name of Exchange on which Registered
Common Stock, $0.001 Par Value	ASMB	The Nasdaq Global Select Market

Securities Registered Pursuant to Section 12(g) of the Act: None

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act. Yes ☐ No ☒

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Exchange Act. Yes ☐ No ☒

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days. Yes ☒ No ☐

Indicate by check mark whether the registrant has submitted electronically every Interactive Data File required to be submitted pursuant to Rule 405 of Regulation S-T (§ 232.45 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit such files). Yes ☒ No ☐

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, a smaller reporting company, or an emerging growth company. See the definitions of "large accelerated filer," "accelerated filer," "smaller reporting company," and "emerging growth company" in Rule 12b-2 of the Exchange Act:

Large accelerated filer	☐	Accelerated filer	☐
Non-accelerated filer	☒	Smaller reporting company	☒
		Emerging growth company	☐

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Indicate by check mark whether the registrant has filed a report on and attestation to its management's assessment of the effectiveness of its internal control over financial reporting under Section 404(b) of the Sarbanes-Oxley Act (15 U.S.C. 7262 (b)) by the registered public accounting firm that prepared or issued its audit report. ☐

If securities are registered pursuant to Section 12(b) of the Act, indicate by check mark whether the financial statements of the registrant included in the filing reflect the correction of an error to previously issued financial statements. ☐

Indicate by check mark whether any of those error corrections are restatements that required a recovery analysis of incentive-based compensation received by any of the registrant's executive officers during the relevant recovery period pursuant to §240.10D-1(b). ☐

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act). Yes ☐ No ☒

The aggregate market value of the voting stock held by non-affiliates of the registrant, as of June 30, 2022, was $100.5 million. Such aggregate market value was computed by reference to the closing price of the common stock as reported on the Nasdaq Global Select Market on June 30, 2022. For purposes of making this calculation only, the registrant has defined affiliates as including only (1) directors, (2) executive officers and (3) certain stockholders, if any, that hold greater than 10% of the voting stock of the registrant, in each case, as of June 30, 2022. Shares of common stock held by other persons, including certain other holders of more than 10% of the registrant's outstanding common stock, if any, have not been excluded from the above calculation in that such persons are not deemed to be affiliates. The determination of affiliate status is not necessarily a conclusive determination for other purposes.

As of March 20, 2023, there were 51,946,918 shares of the registrant's common stock, $0.001 par value per share, outstanding.

DOCUMENTS INCORPORATED BY REFERENCE

Part III of this Annual Report on Form 10-K incorporates information by reference to portions of the definitive proxy statement for the Company's Annual Meeting of Stockholders to be held in 2023, to be filed within 120 days of the registrant's fiscal year ended December 31, 2022.

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ASSEMBLY BIOSCIENCES, INC.
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References to Assembly Biosciences, Inc.

Throughout this Annual Report on Form 10-K, the "Company," "Assembly Bio," "Assembly," "we," "us," and "our," except where the context requires otherwise, refer to Assembly Biosciences, Inc. and its consolidated subsidiaries, and "our board of directors" or "the Board" refers to the board of directors of Assembly Biosciences, Inc.

Forward-Looking Statements

This Annual Report on Form 10-K contains "forward-looking statements" that are subject to certain risks and uncertainties, including, without limitation, those set forth in Part I, Item 1A under the heading "Risk Factors," that could cause actual results to materially differ. Such risks and uncertainties include, among other things:

- our ability to maintain financial resources necessary to continue our research activities, clinical studies and other business operations;
- our ability to initiate and complete clinical studies involving our therapeutic product candidates, including studies contemplated by clinical collaboration agreements, in the anticipated timeframes;
- safety and efficacy data from clinical or nonclinical studies may not warrant further development of our product candidates;
- clinical and nonclinical data presented at conferences may not differentiate our product candidates from other companies' candidates;
- results of nonclinical studies may not be representative of disease behavior in a clinical setting and may not be predictive of the outcomes of clinical studies; and
- continued development and commercialization of ABI-H3733, if successful, in the China territory will be dependent on, and subject to, our collaboration agreement governing our HBV-related activity in the China territory.

You are urged to consider statements that include the words may, will, would, could, should, might, believes, hopes, estimates, projects, potential, expects, plans, anticipates, intends, continues, forecast, designed, goal or the negative of those words or other comparable words to be uncertain and forward-looking. In particular, forward-looking statements include, but are not limited to, statements regarding the timing of commencement of future clinical studies involving our therapeutic product candidates; and our ability to successfully complete, and receive favorable results in, clinical trials for our product candidates. We intend such forward-looking statements to be covered by the safe harbor provisions contained in Section 27A of the Securities Act of 1933, as amended (the Securities Act), and Section 21E of the Securities Exchange Act of 1934, as amended (the Exchange Act). Except as required by law, we assume no obligation to update publicly any forward-looking statements, whether as a result of new information, future events or otherwise.

PART I

Item 1. Business

Overview

We are a biopharmaceutical company advancing clinical candidates with the potential to improve the lives of millions of people living with chronic hepatitis B virus (HBV) infection around the world, an early-stage development program targeting high-recurrence genital herpes associated with herpes simplex virus type 2 (HSV-2) infection and research programs focused on the discovery of novel antivirals to treat devastating viral diseases, including hepatitis delta virus (HDV) and transplant-related herpesviruses.

In July 2022, we implemented a strategic restructuring plan to: (1) discontinue development of our first-generation core inhibitor (CI), vebicorvir (VBR), based on review of interim on-treatment efficacy data from then ongoing triple combination studies that did not support continuation; (2) advance our next-generation CIs, ABI-H3733 (3733) and ABI-4334 (4334), in clinical studies; and (3) prioritize research activities, including our: HBV/HDV entry inhibitor; orally bioavailable, liver-focused interferon-α (IFN-α) receptor (IFNAR) agonist; long-acting HSV-2 helicase inhibitor targeting high-recurrence genital herpes; and programs targeting pan-herpes non-nucleoside polymerase inhibitors (NNPIs) for transplant-associated infections. The strategic plan included a reduction of our workforce by 30 employees, resulting in a total of approximately 70 remaining employees. In connection with the plan, our Chief Medical Officer and Chief Financial Officer stepped down from their roles.

Our Strategic Approaches

Our current business strategy is focused on three parallel paths:

- **Highly Potent Next-Generation HBV Core Inhibitors** – Advancing our novel next-generation CIs in clinical studies, with 4334 (currently prioritized) and 3733 (currently paused) in ongoing Phase 1a and Phase 1b studies, respectively.
- **Novel Small Molecule Approaches for HBV and HDV** – Advancing research programs targeting (1) an orally bioavailable HBV/HDV entry inhibitor and (2) an orally bioavailable, liver-focused IFNAR agonist.
- **Novel Antivirals Targeting Herpesviruses** – Advancing (1) ABI-5366 (5366), a long-acting HSV-2 helicase inhibitor targeting high-recurrence genital herpes to clinical trials, and (2) a research program for pan-herpes NNPIs to treat transplant-associated infections.

HBV Strategy

Inspired by the hundreds of millions of people worldwide living with chronic HBV infection, the goal of our HBV program is to discover and develop finite and curative therapies for these patients. While we have learned that combination therapy with our first-generation CI product candidate, VBR, plus the standard of care, nucleos(t)ide analog reverse transcriptase inhibitor (NrtI), did not result in a finite and curative treatment, we have designed and developed our next-generation CIs for significantly increased potency and ability to engage an additional mechanism of action, targeting the viral reservoir, that VBR could not. We believe that a regimen of our next-generation CIs in combination with NrtI therapy will be the antiviral backbone of future finite and curative therapies. To reach a finite and curative therapy, it may also be necessary to include additional mechanisms of action, whether discovered and developed internally or externally through collaborations, licenses, partnerships and other types of business arrangements.

Development Pipeline Strategy

To complement our CI programs seeking finite and curative chronic HBV therapies, we have leveraged the depth and breadth of our virology expertise to expand our pipeline with a focus on novel mechanisms acting on clinically validated targets in therapeutic areas of high unmet medical need. Since beginning this portfolio expansion in late 2021, we have announced several new programs, both in- and outside of HBV: our HDV/HBV entry inhibitor program, our IFNAR agonist program, our pan-herpes NNPI programs for transplant-associated infections and the long-acting HSV-2 helicase inhibitor for high-recurrence genital herpes. We recently nominated 5366 as a development candidate for our HSV-2 program and look forward to future candidate nominations from our discovery virology pipeline.

We believe that these new programs are compelling complements to our CIs, as each program focuses on a clinically validated target in a virologic disease where innovation is critical to improving patients' lives. In addition, because certain of our new programs are focused on treatments for chronic diseases, rather than curative therapies, the path to proof-of-concept and registrational studies may be significantly shorter than that for our finite and curative HBV therapeutics.

Our HBV and HDV Programs

The World Health Organization (WHO) estimates that 296 million people worldwide are chronically infected with HBV as of 2019, and 1.5 million new infections occur each year. HBV is a leading global cause of chronic liver disease and liver transplants, and the WHO estimates that 820,000 people died in 2019 from HBV, mostly due to cirrhosis and hepatocellular carcinoma. Of the 296 million people living with chronic HBV infection as of 2019, only approximately 30 million were aware of their infection, and only approximately 6.6 million of those diagnosed received treatment. HBV is a highly prevalent disease that infects more than three times the number of people infected with hepatitis C virus and HIV infections combined, according to the WHO, and has a higher morbidity and mortality rate.

The current standard of care for chronic HBV infection, NrtIs, are taken life-long and reduce, but do not eliminate, the virus and result in very low cure rates, leaving an enormous unmet need. No new mechanisms of action (MOA) have been approved for chronic HBV infection in over 25 years. The focus of our HBV program is to improve outcomes and increase the number of patients diagnosed and treated through the development of finite and curative therapies.

We are also progressing two programs with potential application against HDV. HDV is a "satellite virus," because it can only infect people (1) who are already infected with HBV or (2) at the same time as a person is infected with HBV. HDV impacts a subset of approximately 12 million HBV patients. These patients, which only comprise an estimated 4.5% of hepatitis B surface antigen (HBsAg) positive patients, experience a substantially increased disease burden, as they account for 18% of cirrhosis and 20% of hepatocellular carcinoma associated with HBV. In parallel with our efforts to develop finite therapies and functional cures for HBV, we are also advancing programs targeting HDV given the immediate disease burden facing these patients.

The current standard of care treatment for HDV is off-label pegylated IFN-α injected weekly or, in some regions, a large, complex molecule that requires daily injections. We believe a safe and effective oral small molecule entry inhibitor would be a significant innovation for patients living with HDV.

Core Inhibitors

HBV is a DNA virus that infects hepatocytes and establishes a reservoir of covalently closed circular DNA (cccDNA), a unique viral DNA moiety that resides in the cell nucleus of HBV-infected hepatocytes and is associated with viral persistence and chronic infection. No currently approved oral therapies target cccDNA activity directly, which makes molecules that can modulate cccDNA generation or disrupt its function highly sought in the HBV field. As a result, we have worked to discover and develop compounds targeting the core protein, a viral protein involved in numerous aspects of the HBV replication cycle, including the generation of HBV cccDNA. Through our research efforts, we have discovered several chemically distinct series of small molecule CIs that directly target and allosterically inhibit core protein functions. As a result, we believe that our pipeline offers the potential for both first-in-class and best-in-class compounds that target critical steps involved in cccDNA generation and the HBV viral replication cycle.

A benchmark for therapeutic agents aiming to decrease cccDNA levels is the use of several key viral antigens as surrogate biomarkers of active cccDNA. The same biomarkers can be used in both primary human hepatocyte cells and patients. On this basis, our CIs have shown preclinical proof of principle. In a variety of cell culture models, CIs have demonstrated the ability to reduce production of viral HBV DNA levels as well as the surrogate markers for cccDNA establishment: HBV e antigen (HBeAg), HBV core-related antigen (HBcrAg) and viral pre-genomic RNA (pgRNA).

Our research and development organizations are advancing next-generation CIs through clinical development. These candidates, which exhibit multiple MOAs, have been optimized to potently disrupt both viral replication (MOA #1) and, importantly, prevent the establishment and replenishment of new cccDNA (MOA #2). cccDNA is the viral reservoir that drives HBV's life-long persistence in patients. First-generation CIs have not demonstrated adequate potency to sufficiently block its formation. Further, the current standard of care, NrtIs, can only inhibit production of new virus—and do so incompletely.

We leveraged our prior experience with our first-generation CI, VBR, which did not have sufficient potency against MOA #2, in the development of our next-generation CIs. VBR was evaluated in a Phase 2 program with treatment for up to 1.5 years across patient populations and exhibited a favorable safety profile. VBR was observed to be potent against MOA #1 but not MOA #2, and, while it demonstrated greater viral suppression in combination with standard-of-care NrtIs than NrtIs alone, it did not achieve functional cure or finite treatment in our clinical studies. As a result, we discontinued development of VBR. Our two next-generation CIs, 3733 and 4334, were developed to optimize activity against both MOAs and show significantly enhanced potency against both mechanisms preclinically.

3733

3733 was internally discovered and developed. The chemical scaffold of 3733 is novel and distinct from 4334 and both of our discontinued first-generation CI product candidates, VBR and ABI-H2158 (2158).

In preclinical studies, 3733 has demonstrated pan-genotypic activity and an improved resistance profile, as well as significantly increased potency against both MOAs and target coverage as compared to both VBR and 2158. In 2020, we initiated and completed a Phase 1a clinical study of 3733 to evaluate safety, tolerability and pharmacokinetics (PK) following single ascending dose and multiple ascending dose administration in healthy subjects in New Zealand. Data indicated that 3733 was generally well-tolerated and had favorable PK. Results detailing 3733's safety and PK from this study were presented in a poster presentation at the American Association for the Study of Liver Diseases (AASLD) The Liver Meeting® in November 2021 (AASLD 2021). In 2021, following the completion of the Phase 1a trial, our chemistry, manufacturing and controls (CMC) organization developed a new tablet formulation to support Phase 1b for 3733. At the European Association for the Study of the Liver's (EASL) International Liver Congress™ in June 2022 (EASL 2022), we presented 3733's improved PK profile resulting from the new formulation activities mentioned above.

In addition, at EASL's International Liver Congress™ in June 2021 (EASL 2021), we presented observations on 3733's enhanced potency and target coverage for both antiviral activity and inhibition of cccDNA generation as compared to VBR and 2158.

In June 2022, we initiated a randomized, multi-center, double-blind and placebo-controlled Phase 1b trial of 3733 evaluating the safety, PK and antiviral activity of 3733 in adults with cHBV infection, including changes in HBV DNA and other viral parameters associated with 3733 treatment in adults with chronic HBV infection who are treatment naïve or off treatment. Patients were randomized 8:2 between the new tablet formulation of 3733 and placebo for a period of 28 days.

In December 2022, we released interim data from the Phase 1b trial, which consisted primarily of HBeAg negative patients. The dose selected for the first cohort was 50 mg. Given the potent antiviral activity observed at 50 mg, a 25 mg dose was selected for the second cohort to further explore the dose response curve of 3733. A dose of 100 mg was selected for the third cohort.

As of mid-December 2022, dosing in the 3733 Phase 1b trial had been completed for all ten patients in the 50 mg first cohort. Nine of ten patients enrolled were HBeAg negative, so efficacy data was provided for these patients. Interim

efficacy results from this cohort as of mid-December included HBV DNA, HBV RNA and antigen measurements for all patients for the full 28-day dosing period.

In the 50 mg cohort, six of eight patients receiving 3733 achieved HBV DNA less than the lower limit of quantification (<LLOQ) within 21 days, with a mean decline in HBV DNA over the treatment period of approximately 3.1 logs. Data on HBV RNA declines were limited due to low baseline levels in predominantly e-antigen negative patients.

The second cohort, evaluating a dose of 25 mg, was fully enrolled by December 2022. Nine of ten patients enrolled were HBeAg negative. In the five patients that had completed 28 days of treatment as of mid-December 2022, the mean reduction in HBV DNA was approximately 1.9 logs. Data on HBV RNA levels were not available as of mid-December 2022.

The third cohort, evaluating a dose of 100 mg, was fully enrolled by February 2023. Ten of 11 patients enrolled were HBeAg negative so efficacy data were not provided for the single HBeAg positive patient. Interim efficacy results from this cohort as of mid-March included HBV DNA, HBV RNA and antigen measurements for the seven HBeAg negative patients receiving 3733 that had completed 28 days of treatment. All seven patients achieved HBV DNA <LLOQ within 21 days. As all of these patients reached <LLOQ, the mean declines in HBV DNA over the treatment period of approximately 3.0 logs reflect baseline DNA levels and the lower limit of the quantifiable range in this cohort. Data on HBV RNA declines were limited due to low baseline levels in HBeAg negative patients. As expected given the 28-day dosing period, limited changes in viral antigens were observed.

In the 25 mg, 50 mg and 100 mg cohorts through mid-March 2023, all treatment-emergent adverse events (AEs) and laboratory abnormalities reported were Grade 1 or Grade 2. Further, no AEs led to treatment discontinuation, and no clinically significant ECG abnormalities or patterns of AEs or lab abnormalities were noted.

The observed PK for the new tablet formulation of 3733 was consistent with predictions from preclinical studies, providing exposure equivalent to the liquid formulation evaluated in the Phase 1a study for 3733. Available PK data through mid-March 2023 indicated that exposures exhibited dose-proportional increases in the dose range from 25 mg to 100 mg.

As expected, given the 28-day dosing period, limited changes in viral antigens were observed.

A 26-week non-clinical chronic toxicology study of 3733 has been ongoing in parallel with the Phase 1b study. This study revealed a time-dependent toxicity in one species that was not observed in the previous 28-day toxicology study. We continue to evaluate the data; however, proceeding with longer-term dosing of 3733 in a Phase 2 study would require further assessment and likely an additional chronic toxicology study in another species, which would add cost and time to the development timeline for 3733.

In March 2023, based on data to date from the ongoing clinical Phase 1 studies of both 3733 and 4334 and a nonclinical chronic toxicology study of 3733, we have paused core inhibitor candidate 3733 and prioritized core inhibitor candidate 4334.

4334

In mid-2021, we announced the selection of 4334, the second of our next-generation CI product candidates. As with all our CI product candidates nominated after VBR, 4334 was internally discovered and developed. In addition, the chemical scaffold of 4334 is also novel and distinct from VBR, which is licensed from Indiana University, 3733 and 2158.

We nominated 4334 based on a preclinical target drug profile that indicates enhanced target coverage and potency against both MOAs. We believe that 4334 has a best-in-class preclinical profile, with single-digit nanomolar potency against the production of new virus and the formation of cccDNA. Preclinically to date, 4334 has also demonstrated pan-genotypic activity, an improved resistance profile and a favorable safety profile. Preclinical characterization of 4334 was shared in a poster presentation at AASLD in November 2021. At EASL 2022, we presented preclinical data demonstrating that 4334 promotes formation of empty capsids and prevents cccDNA formation by disrupting incoming capsids. At AASLD in November 2022 (AASLD 2022), we presented preclinical data demonstrating that 4334 also accelerates capsid assembly and inhibits cccDNA formation through multiple pathways and showed that

4334 can prematurely disrupt capsids containing dendrimer-like-DNA, which has the potential to impact HBV integration.

In October 2022, we initiated a Phase 1a clinical study of 4334 to evaluate safety, tolerability and PK following single ascending dose and multiple ascending dose administration in healthy subjects in New Zealand.

We shared interim data from this Phase 1a trial at two time points, as of mid-December 2022 for the initial 30 mg single dose cohort and as of mid-March 2023 for all remaining single dose cohorts (100 mg, 200 mg and 400 mg) and the first 100 mg multiple-dose cohort. Dosing has completed for the second and final multiple dose cohort of 200 mg and a food effect cohort at 200 mg is also ongoing. We expect to share safety and PK data from this final multiple dose cohort when available in April 2023.

Based on data available for the single-dose and 100 mg multiple-dose cohorts as of mid-March 2023, 4334 had a mean half-life supporting once-a-day dosing. Based on the PK data from these cohorts and preclinical studies, daily minimum plasma trough concentrations (C_{min}) were projected to achieve double-digit multiples of the protein-adjusted EC_{50} for both MOAs within the dose ranges studied in the Phase 1a study.

Through mid-March 2023, treatment-emergent AEs and laboratory abnormalities were mild to moderate and there were no patterns of AEs or laboratory abnormalities noted and no clinically significant ECG abnormalities were reported.

In March 2023, based on data to date from the ongoing clinical Phase 1 studies of both 3733 and 4334 and a nonclinical chronic toxicology study of 3733, we have prioritized core inhibitor candidate 4334 and paused core inhibitor candidate 3733.

VBR

At the time of our decision to discontinue development of VBR, we had three triple combination studies involving VBR ongoing, two of which were terminated early in 2022. The third triple combination study, Study 204, was subsequently terminated in February 2023. Study 204 was being conducted pursuant to a Clinical Trial Collaboration Agreement with Arbutus Biopharma Corporation (Arbutus Biopharma) and consisted of a randomized, multi-center, open-label Phase 2 clinical study to explore the safety, PK and antiviral activity of the triple combination of VBR, NrtI and AB-729 (Arbutus Biopharma's investigational RNAi candidate) compared to the double combinations of VBR + NrtI and AB-729 + NrtI in virologically suppressed patients. This clinical study was initiated in the first quarter of 2021 and completed enrollment in February 2022. At the time of discontinuation of further VBR clinical development, in consultation with Arbutus Biopharma, we agreed to continue Study 204 and evaluate the primary endpoints of safety and tolerability of the combination regimen. At AASLD 2022, we and Arbutus Biopharma presented an interim analysis of on-treatment data from Study 204. In February 2023, in consultation with Arbutus Biopharma, the companies decided to terminate Study 204 early, at the end of the 48-week on-treatment period, and we are in the process of closing the study.

2158

2158 was a first-generation CI with a chemical scaffold novel and distinct from VBR and both of our next-generation CI product candidates, 3733 and 4334. In September 2021, we discontinued development of 2158 following the observation of elevated alanine transaminase (ALT) levels in the Phase 2 clinical study consistent with drug-induced hepatotoxicity.

Core Inhibitor Collaboration and License Agreements

Indiana University Research and Technology Corporation

In September 2013, we entered into an exclusive license agreement (the IURTC License Agreement) with Indiana University Research and Technology Corporation (IURTC) pursuant to which we acquired, with rights to sublicense, the rights to develop and commercialize products associated with multiple patents and patent applications covering aspects of our HBV program held by IURTC. As part of this agreement, we are obligated to make milestone payments based upon the successful accomplishment of clinical and regulatory milestones. The aggregate amount of all

performance milestone payments under the IURTC License Agreement, should all performance milestones through development be met, is $0.8 million, with a portion having been paid. Under the IURTC License Agreement, we are also obligated to pay IURTC royalties based on net sales of the licensed technology ranging from 0.5% to 1.75%. In addition, under the IURTC License Agreement, we pay annual diligence maintenance fees of $0.1 million. Milestone payments received by IURTC are fully creditable against the annual diligence maintenance fee for the year in which the milestone payments are received.

The IURTC License Agreement may be terminated by us, with or without cause, upon 90 days advance written notice, by IURTC upon our material breach with 60 days advance written notice or by IURTC, in certain cases, upon our insolvency or bankruptcy immediately upon written notice.

BeiGene, Ltd.

In July 2020, we entered into a Collaboration Agreement with BeiGene, granting BeiGene an exclusive, royalty-bearing license to develop and commercialize products containing VBR, 2158 and 3733 (the BeiGene Agreement) in the People's Republic of China, Hong Kong, Taiwan and Macau (the Territory).

Under the BeiGene Agreement, we and BeiGene will collaborate on development activities with respect to the licensed products in accordance with a mutually agreed upon development plan.

Pursuant to the terms of the BeiGene Agreement, BeiGene paid us an upfront amount of $40.0 million, and we were eligible to receive up to approximately $500.0 million in milestone payments, comprised of up to $113.8 million in development and regulatory and $385.0 million in net sales milestone payments. In September 2021, we discontinued development of 2158 following the observation of elevated ALT levels in the Phase 2 clinical study consistent with drug-induced hepatotoxicity, and in July 2022, we discontinued VBR because it did not achieve functional cure or finite treatment in our two- and three-drug combination studies. Due to the discontinuation of development of VBR and 2158, the maximum cash milestone payments we are eligible to receive for 3733 are $285.0 million, comprised of up to $65.0 million for development and regulatory milestones and up to $220.0 million in net sales milestones. In addition, we are eligible to receive tiered royalties at percentages ranging from the mid-teens to the low 30s of net sales. BeiGene has also agreed to pay all development and regulatory costs up to an aggregate of $45.0 million in the Territory for VBR, 2158 and 3733. Following this initial investment, we and BeiGene will share development costs for the Territory equally.

The BeiGene Agreement also contains provisions such as representations and warranties of the parties, terms as to governance of the collaboration, commercialization and regulatory responsibilities of the parties, and manufacturing and supply, including potential adjustments in the event supply costs exceed certain levels. In addition, during the term of the BeiGene Agreement, neither party will commercialize any competing products in the Territory.

Under the terms of the BeiGene Agreement, if after 3733 reaches the end of Phase 2 clinical trials, we and BeiGene are unable to mutually agree on the terms of a Phase 3 global study, BeiGene may elect to terminate the BeiGene Agreement solely as it relates to that compound. Such a termination would result in us regaining all rights to the applicable compound in the Territory. In addition, BeiGene may terminate the BeiGene Agreement for convenience at any time upon 90 days' advance written notice to us. The BeiGene Agreement also contains customary provisions for termination by either party, including in the event of breach of the BeiGene Agreement, subject to cure.

HBV/HDV Entry Inhibitor

In March 2022, we announced our research program focused on a novel, orally bioavailable small molecule approach to inhibit entry of HBV and HDV. While HDV is less prevalent in the United States, it is a significant and serious health problem with inadequate treatment in many parts of Europe, Africa, the Middle East, East Asia and parts of South America. HDV is known to accelerate disease progression and increase the incidence of liver cirrhosis and liver cancer, which results in higher morbidity and mortality rates than HBV alone. The current standard of care treatment for HDV is off-label pegylated IFN-α injected weekly or, in some regions, a large, complex molecule that requires daily injections. We believe a safe and effective oral small molecule entry inhibitor would be a significant innovation for patients living with HDV. Our research team has identified a potential opportunity to develop a safe and effective oral small molecule viral entry inhibitor, which could significantly improve convenience and potentially enhance treatment uptake and diagnosis rates. Based on current progress, our aim is to nominate a product candidate for

development in 2023. At AASLD 2022, we presented the preclinical characterization of our novel class of highly potent small molecule HBV/HDV entry inhibitors.

IFNAR Agonist

In July 2022, we introduced our new research program advancing a novel, small molecule IFNAR agonist designed to selectively activate the IFN-α pathway within the liver and offer the convenience of oral dosing. IFN-α is a subcutaneous injectable immune modularity therapy approved for HBV that has demonstrated functional cure in some HBV patients, but its poor tolerability profile significantly limits its use. Substantial side effects include flu-like symptoms, cytopenias, serious depression and psychiatric effects. In addition, multiple contraindications limit its use, and it requires weekly injections that result in systemic exposure for up to a year.

By focusing exposure on the liver, our investigational IFNAR agonist program aims to engage interferon-α's validated antiviral and immune modulatory mechanisms, retaining the efficacy of IFN-α while reducing systemic exposure to improve tolerability. Lead optimization of multiple agonists is progress. At AASLD 2022, we presented the preclinical characterization of our novel liver-focused small molecule agonists efficiently inhibiting HBV by activating type 1 interferon signaling.

Our Herpesvirus Programs

In August 2022, in addition to announcing our HBV/HDV inhibitor and IFNAR agonist programs, we introduced our first programs outside of hepatitis, which target HSV-2 and transplant-associated herpesviruses.

HSV-2

Up to 40% of patients with genital herpes associated with HSV-2 infection suffer from high-recurrence genital herpes, which results in painful lesions occurring six or more times per year, transmission risk (including neonatal transmission) and increased risk of HIV infection, as well as associated psychological stress.

Helicase-primase inhibitors are antiviral agents with a novel mechanism of action. They inhibit the viral protein complex consisting of helicase, primase, and cofactor subunits, which have functions that are essential for viral DNA replication. These agents are not nucleoside analogues and do not require phosphorylation by the HSV thymidine kinase (TK) to become active drugs; therefore, helicase-primase inhibitors are active immediately upon reactivation of latent HSV. Furthermore, helicase-primase inhibitors are active against TK-deficient HSV, which is a major mechanism of resistance to nucleoside analogues.

Although there are approved antiviral therapies targeting HSV-2, these current therapies are only partially effective in preventing recurrence in patients experiencing high-recurrence genital herpes and require taking one or more pills daily. Due to the limitations of current therapies, we identified an opportunity to develop a potent, long-acting injectable helicase inhibitor with the potential to improve efficacy, convenience and patient compliance. We are targeting long-acting for at least monthly dosing and will continue to evaluate longer dosing intervals as development and formulation progress.

In February 2023, we nominated a development candidate for our HSV-2 long-acting helicase inhibitor program, 5366, for progression into IND-enabling studies.

Transplant-Associated Herpesviruses

In a transplant setting, when patients are experiencing immunosuppression, they are at high risk of uncontrolled viral replication and severe disease brought on by one or more members of the herpesvirus family of viruses including cytomegalovirus (CMV), herpes simplex virus type 1, HSV-2 and varicella zoster virus (VZV). Each of these herpesviruses are highly prevalent, as approximately (1) 60% of the population is CMV-positive; (2) 60% of the population is HSV-positive; and (3) 80% of the population is VZV-positive. These viruses establish lifelong latent infections and frequently reactivate in transplant patients due to immune suppression. These uncontrolled viral infections increase risk of serious complications, including organ rejection and death.

As with HSV-2, there are approved antivirals that are administered in a transplant setting, but they are limited by a narrow spectrum (no approved drug is effective against all of the herpesviruses indicated above), potentially serious

side effects and significant drug-drug interactions. As a result of these limitations, we identified an opportunity to develop an oral pan-herpes NNPI for these transplant-associated herpesvirus infections, which would greatly simplify treatment. Our research team has discovered multiple series of potent, broad-spectrum herpesvirus polymerase inhibitors.

Intellectual Property

We own a U.S. patent application and related foreign patent applications that relate to compositions of matter and methods of using 3733; any patents issuing therefrom are expected to expire in 2039.

We own an international (PCT) application that relates to compositions of matter and methods of using 4334; any patents issuing therefrom are expected to expire in 2041.

We also own provisional patent applications relating to compositions of matter, method of using and pharmaceutical formulations of 5366, and provisional patent applications relating to compositions of matter and method of using our HBV/HDV entry inhibitors, IFNAR agonists and pan-herpes NNPIs.

Government Regulation

Government authorities in the United States, at the federal, state and local level, and in other countries extensively regulate, among other things, the research, development, testing, manufacture, including any manufacturing changes, packaging, storage, recordkeeping, labeling, advertising, promotion, distribution, marketing, post-approval monitoring and reporting, import and export of pharmaceutical products, such as those we are developing.

U.S. drug approval process

In the United States, the FDA regulates drugs under the Federal Food, Drug, and Cosmetic Act (FDCA) and implementing regulations. The process of obtaining regulatory approvals and subsequent compliance with appropriate federal, state, local and foreign statutes and regulations requires the expenditure of substantial time and financial resources. Failure to comply with the applicable U.S. requirements at any time during the product development process, approval process or after approval may subject an applicant or sponsor to a variety of administrative or judicial sanctions, such as the FDA's refusal to approve pending applications, withdrawal of an approval, license revocation, imposition of a clinical hold, issuance of warning letters and untitled letters, product recalls, product seizures, total or partial suspension of production or distribution, injunctions, fines, refusals of government contracts, restitution, disgorgement of profits or civil or criminal penalties.

The process required by the FDA before a drug may be marketed in the United States generally involves the following:

- completion of nonclinical laboratory tests and animal studies in compliance with the FDA's good laboratory practice (GLP) regulations and applicable requirements for the humane use of laboratory animals or other applicable requirements;
- submission to the FDA of an IND which must become effective before human clinical studies may begin;
- approval by an independent institutional review board (IRB) or ethics committee at each clinical site before each trial may be initiated;
- performance of adequate and well-controlled human clinical studies in accordance with good clinical practices (GCP), and any additional requirements for the protection of human research patients and their health information, to establish the safety and efficacy of the proposed drug for each indication;
- submission to the FDA of a new drug application (NDA);
- satisfactory completion of an FDA inspection of the manufacturing facility or facilities at which the product is produced to assess compliance with current good manufacturing practices (cGMP) requirements and to assure that the facilities, methods and controls are adequate to preserve the product's identity, strength, quality and purity; and

- FDA review and approval of the NDA.

Nonclinical studies and IND

Nonclinical studies include laboratory evaluation of product chemistry and formulation, as well as *in vitro* and animal studies to assess the potential for adverse events and in some cases to establish a rationale for therapeutic use. The conduct of nonclinical studies is subject to federal regulations and requirements, including GLP regulations for safety/toxicology studies. An IND sponsor must submit the results of the nonclinical tests, together with manufacturing information, analytical data, any available clinical data or literature and plans for clinical studies, among other things, to the FDA as part of an IND. Some long-term nonclinical testing, such as animal tests of reproductive adverse events and carcinogenicity, may continue after the IND is submitted. For some products, the FDA may waive the need for certain nonclinical tests. An IND automatically becomes effective 30 days after receipt by the FDA, unless before that time the FDA raises concerns or questions related to one or more proposed clinical studies and places the trial on clinical hold. If an IND or clinical study is placed on clinical hold, the IND sponsor and the FDA must resolve any outstanding concerns before the clinical study can begin. As a result, submission of an IND may not result in the FDA allowing clinical studies to commence.

Clinical studies

Clinical studies involve the administration of the investigational new drug to human subjects under the supervision of qualified investigators in accordance with GCP requirements, which include, among other things, the requirement that all research subjects provide their informed consent in writing before their participation in any clinical study. Clinical studies are conducted under written study protocols detailing, among other things, the objectives of the study, the parameters to be used in monitoring safety, and the effectiveness criteria to be evaluated. A protocol for each clinical study and any subsequent protocol amendments must be submitted to the FDA as part of the IND. In addition, an IRB at each institution participating in the clinical study must review and approve the plan for any clinical study before it commences at that institution, and the IRB must conduct continuing review. The IRB must review and approve, among other things, the study protocol and informed consent information to be provided to study subjects. An IRB must operate in compliance with FDA regulations. Information about certain clinical studies must be submitted within specific timeframes to the National Institutes of Health for public dissemination at www.clinicaltrials.gov. The Food and Drug Omnibus Reform Act (FDORA), which was signed into law on December 29, 2022, made numerous amendments to the FDCA including provisions intended to, among other things, decentralize and modernize clinical trials and enhance diversity in clinical trial populations.

Human clinical studies are typically conducted in three sequential phases, which may overlap or be combined:

- *Phase 1:* The drug is initially introduced into healthy human subjects or patients with the target disease or condition and tested for safety, dosage tolerance, absorption, metabolism, distribution, excretion and, if possible, to gain an early indication of its effectiveness.

- *Phase 2:* The drug is administered to a limited patient population to identify possible adverse effects and safety risks, to preliminarily evaluate the efficacy of the product for specific targeted diseases and to determine dosage tolerance and optimal dosage.

- *Phase 3:* The drug is administered to an expanded patient population in adequate and well-controlled clinical studies to generate sufficient data to statistically confirm the efficacy and safety of the product for approval, to establish the overall risk-benefit profile of the product and to provide adequate information for the labeling of the product.

Progress reports detailing the results of the clinical studies must be submitted at least annually to the FDA. Additionally, IND safety reports must be submitted to the FDA and the investigators within 15 calendar days after determining that the information qualifies for reporting. IND safety reports are required for serious and unexpected suspected adverse reactions, findings from animal or *in vitro* testing or other studies that suggest a significant risk to humans, and any clinically important increase in the rate of a serious suspected adverse reaction over that listed in the protocol or investigator brochure. In addition, a sponsor must notify the FDA within seven calendar days after receiving information concerning any unexpected fatal or life-threatening suspected adverse reaction. Phase 1, Phase 2 and Phase 3 clinical studies may not be completed successfully within any specified period, or at all. Furthermore,

the FDA or the sponsor may suspend or terminate a clinical study at any time on various grounds, including a finding that the research subjects are being exposed to an unacceptable health risk. Similarly, an IRB can suspend or terminate approval of a clinical study at its institution if the clinical study is not being conducted in accordance with the IRB's requirements or if the drug has been associated with unexpected serious harm to patients.

A manufacturer of an investigational drug for a serious disease or condition is required to make available, such as by posting on its website, its policy regarding evaluating and responding to requests for individual patient access to such investigational drug. This requirement applies on the earlier of the first initiation of a Phase 2 or Phase 3 trial of the investigational drug or, as applicable, 15 days after the drug receives a designation as a breakthrough therapy, Fast Track product, or regenerative advanced therapy.

Marketing approval

After the completion of required clinical testing, the results of the nonclinical studies and clinical studies, together with detailed information relating to the product's chemistry, manufacture, controls and proposed labeling, among other things, are submitted to the FDA as part of an NDA requesting approval to market the product for one or more indications. Under federal law, the submission of most NDAs is additionally subject to a substantial application user fee, currently $3.2 million and the sponsor of an approved NDA is also subject to an annual program fee currently set at $0.4 million through September 30, 2023. These fees are typically adjusted on October 1 each year.

The FDA conducts a preliminary review of all NDAs within the first 60 days after submission before accepting them for filing to determine whether they are sufficiently complete to permit substantive review. The FDA may request additional information rather than accept an NDA for filing. In this event, the application must be resubmitted with the additional information. The resubmitted application is also subject to review before the FDA accepts it for filing. Once the submission is accepted for filing, the FDA begins an in-depth substantive review. The FDA has agreed to specified performance goals in the review of NDAs. Under these goals, the FDA has committed to review most original applications for non-priority products within ten months, and most original applications for priority review products, that is, drugs for a serious or life-threatening condition that the FDA determines represent a significant improvement over existing therapy, within six months. For NDAs for novel products, the ten- and six-month time periods runs from the filing date; for all other original applications, the ten- and six-month time periods run from the submission date. The review process may be extended by the FDA for three additional months to consider certain information or clarification regarding information already provided in the submission. Despite these review goals, it is not uncommon for FDA review of an NDA to extend beyond the goal date. The FDA may also refer applications for novel drugs or products that present difficult questions of safety or efficacy to an advisory committee, typically a panel that includes clinicians and other experts, for review, evaluation and a recommendation as to whether the application should be approved. The FDA is not bound by the recommendations of an advisory committee, but it considers such recommendations carefully when making decisions.

Before approving an NDA, the FDA typically will inspect the facility or facilities where the product is manufactured. The FDA will not approve an application unless it determines that the manufacturing processes and facilities are in compliance with cGMP requirements and adequate to assure consistent production of the product within required specifications. In addition, before approving an NDA, the FDA will typically inspect one or more clinical sites to assure compliance with GCP and integrity of the clinical data submitted. With passage of the FDORA, Congress clarified the FDA's authority to conduct inspections by expressly permitting inspection of facilities involved in the preparation, conduct, or analysis of clinical and non-clinical studies submitted to FDA as well as other persons holding study records or involved in the study process.

After the FDA's evaluation of the NDA and inspection of the manufacturing facilities, the FDA may issue an approval letter or a complete response letter. An approval letter authorizes commercial marketing of the drug with specific prescribing information for specific indications. A complete response letter generally outlines the deficiencies in the submission and may require substantial additional testing or information in order for the FDA to reconsider the application. If and when those deficiencies have been addressed to the FDA's satisfaction in a resubmission of the NDA, the FDA will issue an approval letter. The FDA has committed to reviewing such resubmissions in two or six months depending on the type of information included. Even with submission of this additional information, the FDA ultimately may decide that the application does not satisfy the regulatory criteria for approval and refuse to approve the NDA. Even if the FDA approves a product, it may limit the approved indications for use for the product, require that contraindications, warnings or precautions be included in the product labeling, require that post-approval studies,

including Phase 4 clinical studies, be conducted to further assess a drug's safety after approval, require testing and surveillance programs to monitor the product after commercialization, or impose other conditions, including distribution and use restrictions or other risk management mechanisms, including Risk Evaluation and Mitigation Strategies (REMS), which can materially affect the potential market and profitability of the product or impose new labeling, testing or distribution and use requirements. The FDA may prevent or limit further marketing of a product based on the results of post-market studies or surveillance programs. After approval, some types of changes to the approved product, such as adding new indications, manufacturing changes and additional labeling claims, are subject to further testing requirements and FDA review and approval.

Fast Track designation

The FDA is required to facilitate and expedite the development and review of drugs that are intended for the treatment of a serious or life-threatening disease or condition for which there is no effective treatment and which demonstrate the potential to address unmet medical needs for the disease or condition. Under the Fast Track program, the sponsor of a new product candidate may request the FDA to designate the product for a specific indication as a Fast Track product concurrent with or after the filing of the IND for the product candidate. The FDA must determine if the product candidate qualifies for fast track designation within 60 calendar days after receipt of the sponsor's request.

In addition to other benefits, such as the ability to have greater interactions with the FDA, the FDA may initiate review of sections of a Fast Track product's NDA before the application is complete. This rolling review is available if the applicant provides and the FDA approves a schedule for the submission of the remaining information and the applicant pays applicable user fees. However, the FDA's time period goal for reviewing a Fast Track application does not begin until the last section of the NDA is submitted. In addition, the Fast Track designation may be withdrawn by the FDA if the FDA believes that the designation is no longer supported by data emerging in the clinical study process. In 2018, the FDA granted Fast Track designation to VBR for the treatment of patients with chronic HBV infection.

Priority review

Under FDA policies, a product candidate may be eligible for priority review, a review generally within a six-month time frame from the time a complete application is received or filed. Products generally are eligible for priority review if they are intended for treatment of a serious or life-threatening disease or condition and provide a significant improvement in safety or effectiveness compared to marketed products in the treatment, diagnosis or prevention of a serious disease or condition.

Accelerated approval

Under the FDA's accelerated approval regulations, the FDA may approve a drug for a serious or life-threatening illness that provides meaningful therapeutic benefit to patients over existing treatments based upon a surrogate endpoint that is reasonably likely to predict clinical benefit or on a clinical endpoint that can be measured earlier than irreversible morbidity or mortality (IMM). In clinical studies, a surrogate endpoint is a measurement of laboratory or clinical signs of a disease or condition that substitutes for a direct measurement of how a patient feels, functions or survives. Surrogate endpoints can often be measured more easily or more rapidly than clinical endpoints. A product candidate approved on this basis is subject to rigorous post-marketing compliance requirements, including the completion of Phase 4 or post-approval clinical studies to confirm the effect on the clinical endpoint. Failure to conduct required post-approval studies, or confirm a clinical benefit during post-marketing studies, would allow the FDA to withdraw the drug from the market on an expedited basis. All promotional materials for drug candidates approved under accelerated regulations are subject to prior review by the FDA. With the passage of the FDORA, the FDA is authorized to require a post-approval study to be underway prior to approval or within a specified time period following approval. FDORA also requires the FDA to specify conditions of any required post-approval study and requires sponsors to submit progress reports for required post-approval studies and any conditions required by the FDA until completion or termination of the study. FDORA further enables the FDA to initiate criminal prosecutions for the failure to conduct with due diligence a required post-approval study, including a failure to meet any required conditions specified by the FDA or to submit timely reports.

Breakthrough therapy designation

A sponsor can request designation of a product candidate as a "breakthrough therapy." A breakthrough therapy is defined as a drug that is intended, alone or in combination with one or more other drugs, to treat a serious or life-threatening disease or condition, and preliminary clinical evidence indicates that the drug may demonstrate substantial improvement over existing therapies on one or more clinically significant endpoints, such as substantial treatment effects observed early in clinical development. Drugs designated as breakthrough therapies also may be eligible for priority review. The FDA must take certain actions, such as holding timely meetings and providing advice, intended to expedite the development and review of an application for approval of a breakthrough therapy. Even if a product qualifies for one or more of these programs, the FDA may later decide that the product no longer meets the conditions for qualification or decide that the time period for FDA review or approval will not be shortened.

Orphan drugs

Under the Orphan Drug Act, as amended, the FDA may grant orphan drug designation to drugs intended to treat a rare disease or condition, which is generally defined as a disease or condition that affects fewer than 200,000 individuals in the United States or that affects more than 200,000 individuals in the United States and for which there is no reasonable expectation that the cost of developing and making available the drug for the disease or condition will be recovered from sales of the product in the United States. Orphan drug designation must be requested before submitting an NDA or BLA. After the FDA grants orphan drug designation, the identity of the product and its potential orphan use are disclosed publicly by the FDA. Orphan drug designation does not shorten the duration of the regulatory review and approval process. The first NDA or BLA applicant to receive FDA approval for a particular active moiety to treat a particular disease with FDA orphan drug designation is entitled to a seven-year exclusive marketing period in the United States for that product and indication. During the seven-year exclusivity period, the FDA may not approve any other applications to market the same drug for the same orphan indication, except in limited circumstances, such as a showing of clinical superiority to the product with orphan drug exclusivity. A drug will be considered clinically superior if it is shown to be safer, more effective or makes a major contribution to patient care. Orphan drug exclusivity does not prevent the FDA from approving a different drug for the same orphan disease or condition, or the same drug for a different disease or condition. Among the other benefits of orphan drug designation are tax credits for certain research and a waiver of the NDA/BLA application user fee.

Pediatric information

Under the Pediatric Research Equity Act of 2003, as amended, an NDA or supplement to an NDA for drug with certain novel features (e.g., new active ingredient, new indication) must contain data that are adequate to assess the safety and effectiveness of the drug for the claimed indications in all relevant pediatric subpopulations, and to support dosing and administration for each pediatric subpopulation for which the product is safe and effective. The FDA may, on its own initiative or at the request of the applicant, grant deferrals for submission of some or all pediatric data until after approval of the product for use in adults, or full or partial waivers from the pediatric data requirements. A sponsor of a new drug subject to the above pediatric testing requirements also is required to submit to the FDA a pediatric study plan generally 60 days after an end-of-Phase 2 meeting with the agency. Generally, the pediatric data requirements do not apply to products with orphan drug designation.

Other regulatory requirements

Any drug manufactured or distributed by us pursuant to FDA approvals will be subject to pervasive and continuing regulation by the FDA, including, among other things, requirements relating to recordkeeping, periodic reporting, product sampling and distribution, advertising and promotion and reporting of adverse experiences with the product. After approval, most changes to the approved product, such as adding new indications or other labeling claims, are subject to prior FDA review and approval.

The FDA may impose a number of post-approval requirements, including REMS, as a condition of approval of an NDA or BLA. For example, the FDA may require post-marketing testing, including Phase 4 clinical studies, and surveillance to further assess and monitor the product's safety and effectiveness after commercialization.

In addition, drug manufacturers and other entities involved in the manufacture and distribution of approved drugs are required to register their establishments with the FDA and state agencies and are subject to periodic unannounced

inspections by the FDA and these state agencies for compliance with cGMP requirements. Changes to the manufacturing process are strictly regulated and often require prior FDA approval before being implemented. FDA regulations also require investigation and correction of any deviations from cGMP and impose reporting and documentation requirements upon us and any third-party manufacturers that we may decide to use. Accordingly, manufacturers must continue to expend time, money and effort in the areas of production and quality control to maintain cGMP compliance.

Once an approval is granted, the FDA may withdraw the approval if compliance with regulatory requirements and standards is not maintained or if problems occur after the product reaches the market. Later discovery of previously unknown problems with a product, including adverse events of unanticipated severity or frequency, or with manufacturing processes, or failure to comply with regulatory requirements, may result in revisions to the approved labeling to add new safety information, imposition of post-market studies or clinical studies to assess new safety risks or imposition of distribution or other restrictions under a REM program. Other potential consequences include, among other things:

- restrictions on the marketing or manufacturing of the product, complete withdrawal of the product from the market or product recalls;
- fines, warning letters or holds on post-approval clinical studies;
- refusal of the FDA to approve pending applications or supplements to approved applications, or suspension or revocation of product approvals;
- product seizure or detention, or refusal to permit the import or export of products; or
- consent decrees, injunctions or the imposition of civil or criminal penalties.

The FDA strictly regulates marketing, labeling, advertising and promotion of products that are placed on the market. Drugs generally may be promoted only for the approved indications and in accordance with the provisions of the approved labeling. The FDA and other agencies actively enforce the laws and regulations prohibiting the promotion of off label uses, and a company that is found to have improperly promoted off label uses may be subject to significant liability.

Physician Drug Samples

As part of the sales and marketing process, pharmaceutical companies frequently provide samples of approved drugs to physicians. The Prescription Drug Marketing Act (PDMA) regulates the distribution of drug samples at the federal level and sets minimum standards for the registration and regulation of drug distributors by the states. Both the PDMA and state laws limit the distribution of prescription pharmaceutical product samples and impose requirements to ensure accountability in distribution. In addition, the PDMA sets forth civil and criminal penalties for violations.

Foreign Regulation

In order to market any product outside of the United States, we would need to comply with numerous and varying regulatory requirements of other countries regarding safety and efficacy and governing, among other things, clinical studies, marketing authorization, commercial sales and distribution of our products. Whether or not we obtain FDA approval for a product, we would need to obtain the necessary approvals by the comparable regulatory authorities of foreign countries before we can commence clinical studies or marketing of the product in those countries. The approval process varies from country to country and can involve additional product testing and additional administrative review periods. The time required to obtain approval in other countries might differ from and be longer than that required to obtain FDA approval. Regulatory approval in one country does not ensure regulatory approval in another, but a failure or delay in obtaining regulatory approval in one country may negatively impact the regulatory process in others.

Pharmaceutical Coverage, Pricing and Reimbursement

Significant uncertainty exists as to the coverage and reimbursement status of any drug products for which we may obtain regulatory approval. Sales of any of our product candidates, if approved, will depend, in part, on the extent to which the costs of the products will be covered by third-party payors, including government health programs such as

Medicare and Medicaid, commercial health insurers and managed care organizations. The process for determining whether a payor will provide coverage for a drug product may be separate from the process for setting the price or reimbursement rate that the payor will pay for the drug product once coverage is approved. Third-party payors may limit coverage to specific drug products on an approved list, or formulary, which might not include all of the approved drugs for a particular indication.

The containment of healthcare costs has become a priority of federal, state and foreign governments, and the prices of drugs have been a focus in this effort. Third-party payors are increasingly challenging the prices charged for medical products and services and examining the medical necessity and cost-effectiveness of medical products and services, in addition to their safety and efficacy. Accordingly, we may need to conduct expensive pharmacoeconomic studies in order to demonstrate the medical necessity and cost-effectiveness of our product candidates, in addition to the trials required to obtain FDA or other comparable regulatory approvals. If these third-party payors do not consider our products to be cost-effective compared to other available therapies, they may not cover our products after approval as a benefit under their plans or, if they do, the level of payment may not be sufficient to enable us to maintain price levels high enough to realize an appropriate return on our investment in product development. Further, one payor's determination to provide coverage for a product, if approved, does not assure that other payors will also provide coverage and reimbursement for the product, and the level of coverage and reimbursement can differ significantly from payor to payor.

Pricing and reimbursement schemes vary widely from country to country. Some countries provide that drug products may be marketed only after a reimbursement price has been agreed. Some countries may require the completion of additional studies that compare the cost-effectiveness of a particular product candidate to currently available therapies. For example, the European Union provides options for its member states to restrict the range of drug products for which their national health insurance systems provide reimbursement and to control the prices of medicinal products for human use. European Union member states may approve a specific price for a drug product or may instead adopt a system of direct or indirect controls on the profitability of us placing the drug product on the market. Other member states allow companies to fix their own prices for drug products but monitor and control company profits. The downward pressure on health care costs in general, particularly prescription drugs, has become very intense. As a result, increasingly high barriers are being erected to the entry of new products. In addition, in some countries, cross-border imports from low-priced markets exert competitive pressure that may reduce pricing within a country. There can be no assurance that any country that has price controls or reimbursement limitations for drug products will allow favorable reimbursement and pricing arrangements for any of our products.

The marketability of any products for which we may receive regulatory approval for commercial sale is dependent on the availability of adequate coverage and reimbursement from government and third-party payors. In addition, the emphasis on managed care in the United States has increased and we expect will continue to increase the pressure on drug pricing. Coverage policies, third-party reimbursement rates and drug pricing regulation may change at any time. For example the Affordable Care Act of 2010, as amended by, the Health Care and Education Reconciliation Act (collectively, ACA), among other things, imposed an annual fee on any entity that manufactures or imports certain branded prescription drugs, increased the minimum Medicaid rebates owed by most manufacturers under the Medicaid Drug Rebate Program, under the Medicare Part D coverage gap discount program. In addition to these provisions, the ACA established a number of bodies whose work may have a future impact on the market for certain pharmaceutical products, including the Patient-Centered Outcomes Research Institute, established to oversee, identify priorities in, and conduct comparative clinical effectiveness research, and the Center for Medicare and Medicaid Innovation within the Centers for Medicare and Medicaid Services, established to test innovative payment and service delivery models to lower Medicare and Medicaid spending.

Since its enactment, there have been executive, judicial, and Congressional challenges to certain aspects of the ACA. For example, former President Trump issued directives designed to delay the implementation of certain PPACA provisions or otherwise circumvent requirements for health insurance mandated by the PPACA, and Congress has considered legislation that would repeal, or repeal and replace all or part of the ACA. While Congress has not passed comprehensive repeal legislation, several bills affecting the implementation of certain taxes under the ACA have been signed into law. For example, the Tax Cuts and Jobs Act, effectively repealed the individual health insurance mandate, which is considered a key component of the ACA. On December 14, 2018, a U.S. District Court Judge in the Northern District of Texas ruled that the individual mandate is a critical and inseverable feature of the ACA, and because it was repealed as part of the Tax Act, the remaining provisions of the ACA are invalid as well. In December 2019, the U.S. Court of Appeals for the Fifth Circuit upheld the lower court decision, which was then appealed to the U.S. Supreme

Court. On June 17, 2021, the U.S. Supreme Court held that state and individual plaintiffs did not have standing to challenge the individual mandate provision of the ACA; in so holding, the Supreme Court did not consider larger constitutional questions about the validity of this provision or the validity of the ACA in its entirety. Another case challenging the PPACA's requirement that insurers cover certain preventative services is currently pending before the same U.S. District Court Judge in the Northern District of Texas who ruled against the individual mandate in 2018. In September 2022, the judge held that certain preventative services violated the U.S. Constitution and set a schedule for additional briefing that continued into January 2023. It is unclear how this or any potential future litigation and other efforts to repeal and replace the PPACA will impact the PPACA. Further, the Trump Administration's 2020 federal spending package permanently eliminated, effective January 1, 2020, the ACA-mandated "Cadillac" tax on certain high-cost employer-sponsored insurance plans and, on January 1, 2021, eliminated the health insurer tax.

In addition, other legislative changes have been proposed and adopted since the ACA was enacted. These changes included aggregate reductions to Medicare payments to providers of up to 2% per fiscal year, and, due to subsequent legislative amendments, will remain in effect through 2031, with the exception of a temporary suspension from May 1, 2020 through March 2021, due to the COVID-19 pandemic. Further, in January 2013, then President Obama signed into law the American Taxpayer Relief Act of 2012, which, among other things, reduced Medicare payments to several providers, and increased the statute of limitations period for the government to recover overpayments to providers from three to five years. These laws may result in additional reductions in Medicare and other healthcare funding and otherwise affect the prices we may obtain for any of our product candidates for which we may obtain regulatory approval or the frequency with which any such product candidate is prescribed or used.

Additionally, there has been increasing legislative and enforcement interest in the United States with respect to drug pricing practices. Specifically, there have been several recent United States Congressional inquiries and proposed and enacted federal legislation designed to, among other things, bring more transparency to drug pricing, reduce the cost of prescription drugs under Medicare, review the relationship between pricing and manufacturer patient programs, and reform government program reimbursement methodologies for drugs. For example, the Inflation Reduction Act of 2022, or IRA, enacted on August 16, 2022, seeks to reduce prescription drug costs by, among other provisions, allowing Medicare to negotiate prices for certain high-cost prescription drugs in Medicare Parts B and D, imposing an excise tax on pharmaceutical manufacturers that refuse to negotiate pricing with Medicare, and requiring inflation rebates to limit annual drug price increases in Medicare. Beginning in 2025, the IRA also eliminates the coverage gap under Medicare Part D by significantly lowering the enrollee maximum out-of-pocket cost and imposing on new manufacturer discount program. In addition, in September 2020, the FDA issued a final rule that sets up a legal framework for allowing the importation of certain prescription drugs from Canada, and the Centers for Medicare & Medicaid Services (CMS) issued guidance that addresses the treatment of certain imported drugs under the Medicaid Drug Rebate Program.

Although a number of these and other proposed measures may require authorization through additional legislation to become effective, and the Biden administration may reverse or otherwise change these measures, both the Biden administration and Congress have indicated that they will continue to seek new legislative measures to control drug costs.

At the state level, individual states are increasingly aggressive in passing legislation and implementing regulations designed to control pharmaceutical product pricing, including price or patient reimbursement constraints, discounts, restrictions on certain product access and marketing cost disclosure and transparency measures. These measures could reduce the ultimate demand for our products, if approved, or put pressure on our product pricing. We expect that additional state and federal healthcare reform measures will be adopted in the future, any of which could limit the amounts that federal and state governments will pay for healthcare products and services, which could result in reduced demand for our product candidates or additional pricing pressures.

Other Healthcare Laws

In the United States, our activities are potentially subject to regulation by various federal, state and local authorities in addition to the FDA, including but not limited to, CMS, other divisions of the U.S. Department of Health and Human Services (e.g., the Office of Inspector General), the U.S. Department of Justice (DOJ), and individual U.S. Attorney offices within the DOJ, and state and local governments. For example, the Company's business practices, including its research and sales, marketing and scientific/ educational grant programs may be required to comply with federal and state fraud and abuse laws, false claims laws, the data privacy and security provisions of the Health

Insurance Portability and Accountability Act (HIPAA), federal transparency requirements and similar state laws, each as amended. The laws that may affect our ability to operate include:

- the federal Anti-Kickback Statute, which prohibits, among other things, knowingly and willfully soliciting, receiving, offering or paying any remuneration (including any kickback, bribe, or rebate), directly or indirectly, overtly or covertly, in cash or in kind, to induce, or in return for, either the referral of an individual, or the purchase, lease, order or recommendation of any good, facility, item or service for which payment may be made, in whole or in part, under a federal healthcare program, such as the Medicare and Medicaid programs. A person or entity can be found guilty of violating the statute without actual knowledge of the statute or specific intent to violate it. The Anti-Kickback Statute has been interpreted to apply to arrangements between pharmaceutical manufacturers on the one hand and prescribers, purchasers, and formulary managers on the other;

- federal civil and criminal false claims laws and civil monetary penalty laws, such as the federal False Claims Act, which impose criminal and civil penalties and authorize civil whistleblower or qui tam actions, against individuals or entities for, among other things: knowingly presenting, or causing to be presented, to the federal government, claims for payment that are false or fraudulent; making a false statement or record material to a false or fraudulent claim or obligation to pay or transmit money or property to the federal government; or knowingly concealing or knowingly and improperly avoiding or decreasing an obligation to pay money to the federal government. In addition, the government may assert that a claim including items and services resulting from a violation of the federal Anti-Kickback Statute constitutes a false or fraudulent claim for purposes of the False Claims Act. Manufacturers can be held liable under the False Claims Act even when they do not submit claims directly to government payors if they are deemed to "cause" the submission of false or fraudulent claims;

- HIPAA, which created new federal criminal statutes that prohibit knowingly and willfully executing, or attempting to execute, a scheme to defraud any healthcare benefit program or obtain, by means of false or fraudulent pretenses, representations, or promises, any of the money or property owned by, or under the custody or control of, any healthcare benefit program, regardless of the payor (e.g., public or private) and knowingly and willfully falsifying, concealing or covering up by any trick or device a material fact or making any materially false statements in connection with the delivery of, or payment for, healthcare benefits, items or services relating to healthcare matters. Similar to the federal Anti-Kickback Statute, a person or entity can be found guilty of violating HIPAA without actual knowledge of the statute or specific intent to violate it;

- HIPAA, as amended by HITECH, and their respective implementing regulations, which impose requirements on certain covered healthcare providers, health plans, and healthcare clearinghouses as well as their respective business associates that perform services for them that involve the use, or disclosure of, individually identifiable health information, relating to the privacy, security and transmission of individually identifiable health information. HITECH also created new tiers of civil monetary penalties, amended HIPAA to make civil and criminal penalties directly applicable to business associates, and gave state attorneys general new authority to file civil actions for damages or injunctions in federal courts to enforce the federal HIPAA laws and seek attorneys' fees and costs associated with pursuing federal civil actions;

- the federal false statements statute prohibits knowingly and willfully falsifying, concealing or covering up a material fact or making any materially false statement in connection with the delivery of or payment for healthcare benefits, items or services;

- the U.S. federal Food, Drug and Cosmetic Act (FDCA), which prohibits, among other things, the adulteration or misbranding of drugs, biologics and medical devices;

- the federal transparency requirements under the ACA, including the provision commonly referred to as the Physician Payments Sunshine Act, which requires manufacturers of drugs, devices, biologics and medical supplies for which payment is available under Medicare, Medicaid or the Children's Health Insurance Program to report annually to the U.S. Department of Health and Human Services information related to payments or other transfers of value made to physicians and teaching hospitals, as well as ownership and investment interests held by physicians and their immediate family members. Effective January 1, 2022,

these reporting obligations will extend to include transfers of value made to certain non-physician providers such as physician assistants and nurse practitioners; and

- federal consumer protection and unfair competition laws, which broadly regulate marketplace activities and activities that potentially harm consumers.

Additionally, we are subject to state and non-U.S. equivalents of each of the healthcare laws described above, among others, some of which may be broader in scope and may apply regardless of the payor. Many U.S. states have adopted laws similar to the federal Anti-Kickback Statute, some of which apply to the referral of patients for healthcare services reimbursed by any source, not just governmental payors, including private insurers. In addition, some states have passed laws that require pharmaceutical companies to comply with the April 2003 Office of Inspector General Compliance Program Guidance for Pharmaceutical Manufacturers and/or the Pharmaceutical Research and Manufacturers of America's Code on Interactions with Healthcare Professionals. Several states also impose other marketing restrictions or require pharmaceutical companies to make marketing or price disclosures to the state. There are ambiguities as to what is required to comply with these state requirements and if we fail to comply with an applicable state law requirement, we could be subject to penalties.

In addition, regulators globally are also imposing greater monetary fines for privacy violations. The General Data Protection Regulation (GDPR), which went into effect on May 25, 2018, applies to any company established in the European Union (EU) as well as to those outside the EU if they collect and use personal data in connection with the offering goods or services to individuals in the EU or the monitoring of their behavior. The GDPR enhances data protection obligations for processors and controllers of personal data, including, for example, expanded disclosures about how personal information is to be used, limitations on retention of information, mandatory data breach notification requirements and onerous new obligations on services providers. Noncompliance with the GDPR may result in monetary penalties of up to €20 million or 4% of worldwide revenue, whichever is higher. The GDPR also confers a private right of action on data subjects and consumer associations to lodge complaints with supervisory authorities, seek judicial remedies, and obtain compensation for damages resulting from violations. In addition, the GDPR includes restrictions on cross-border data transfers. The GDPR may increase our responsibility and liability in relation to personal data that we process where such processing is subject to the GDPR, and we may be required to put in place additional mechanisms to ensure compliance with the GDPR, including as implemented by individual countries.

California enacted the California Consumer Privacy Act (CCPA), which creates new individual privacy rights for California consumers (as defined in the law) and places increased privacy and security obligations on entities handling personal data of consumers or households. The CCPA will require covered companies to provide certain disclosures to consumers about its data collection, use and sharing practices, and to provide affected California residents with ways to opt-out of certain sales or transfers of personal information. While there is currently an exception for protected health information that is subject to HIPAA and clinical trial regulations, as currently written, the CCPA may impact our business activities. Additionally, the California Privacy Rights Act (CPRA), which went into effect on January 1, 2023, imposes additional obligations on companies covered by the legislation and expands consumers' rights with respect to certain sensitive personal information, among other things. The CPRA also creates a new state agency that will be vested with authority to implement and enforce the CCPA and the CPRA. Other states, including Virginia and Colorado have similarly passed data privacy laws that will regulate how businesses collect and share personal information.

New Legislation and Regulations

From time to time, legislation is drafted, introduced and passed in Congress that could significantly change the statutory provisions governing the testing, approval, manufacturing, marketing, and reimbursement status of products regulated by the FDA. In addition to new legislation, FDA regulations and policies are often revised or interpreted by the agency in ways that may significantly affect our business and our products. It is impossible to predict whether further legislative changes will be enacted or whether FDA regulations, guidance, policies or interpretations will be changed or what the effect of such changes, if any, may be.

Competition

The pharmaceutical and biotechnology industry is very competitive, and the development and commercialization of new drugs is influenced by rapid technological developments and innovation. We face competition from several companies developing and commercializing products that will be competitive with our drug candidates, including large pharmaceutical and smaller biotechnology companies. Additionally, new entrants may potentially enter the market. Potential competitors include Johnson & Johnson, Roche, Gilead Sciences Inc., GlaxoSmithKline plc, Enanta Pharmaceuticals, Inc., HEC Pharma, Arbutus Biopharma, Vir Bio, Aligos Therapeutics, AiCuris Anti-infective Cures AG, and Qilu Pharmaceutical, among others. Additionally, we may face competition from currently available HBV treatments. Some of the competitive development programs from these companies may be based on scientific approaches that are similar to our approach, and others may be based on entirely different approaches. Potential competitors also include academic institutions, government agencies and other public and private research organizations that conduct research, seek patent protection and establish collaborative arrangements for research, development, manufacturing and commercialization of products similar to ours or that otherwise target indications that we are pursuing.

Manufacturing

We currently rely on third-party manufacturers to supply the quantities of our investigational product candidates used in our clinical and nonclinical studies. We currently have no plans to establish any manufacturing facilities for our product candidates.

Human Capital Management

As of December 31, 2022, we had 68 total employees and contracts with a number of temporary contractors, consultants and contract research organizations (CROs). The majority of our employees work out of our facility in South San Francisco, California. We also have a small number of remote employees spread across the United States and one remote employee in the United Kingdom.

We continually evaluate our needs and make strategic choices regarding whether to hire internal teams or outsource certain functions to CROs or contract manufacturing organizations (CMOs), as appropriate. We currently outsource our clinical study management to various CROs and utilize certain CMOs to manufacture both the drug substance and the drug product used in our ongoing and planned clinical studies.

We compete with both large and small companies in our industry for a limited number of qualified applicants to fill highly specialized needs. We generally target our base salaries and annual performance-based cash bonuses at the 50th percentile of our peers and our long-term equity incentive compensation, which all employees receive, between the 50th and 75th percentiles of our peers. In certain circumstances, we offer compensation above these levels, based on a candidate's experience, criticality, amount of responsibility and either individual or Company-wide performance. We routinely review our employees' base salaries to ensure that they remain market competitive. Both annual performance-based cash bonuses and long-term equity compensation increase as a percentage of total compensation based on employees' levels of responsibility. We also offer comprehensive benefits packages to all of our employees, including: 100% Company-covered medical, dental and vision coverage for employees and their families; a 401k program with a Company match; a comprehensive employee assistance program, an employee stock purchase plan; and paid family leave.

A large majority of our employees have advanced degrees, and we also offer an educational assistance program that reimburses employees up to a maximum amount per year for courses that directly enhance his or her area of professional work or contribute to his or her immediate career growth. This program demonstrates our commitment to analytical growth, enhanced knowledge and professional development.

Corporate History

We were incorporated in Delaware in October 2005 under the name South Island Biosciences, Inc. (which was changed to Ventrus Biosciences, Inc. in April 2007). On July 11, 2014, we acquired Assembly Pharmaceuticals, Inc., a private company, through a merger with our wholly owned subsidiary (the Merger). In connection with the Merger, we changed our name from Ventrus Biosciences, Inc. to Assembly Biosciences, Inc.

Corporate Information

Our principal executive office is at 331 Oyster Point Blvd., Fourth Floor, South San Francisco, California 94080. Our telephone number is (833) 509-4583.

Available Information

Our website address is www.assemblybio.com. We routinely post, or have posted, important information for investors on our website in the "Investors" section. We use this website as a means of disclosing material information in compliance with our disclosure obligations under Regulation FD. Accordingly, investors should monitor the "Investors" section of our website, in addition to following our press releases, Securities and Exchange Commission (SEC) filings, presentations and webcasts. We make available free of charge through our website our press releases, Annual Reports on Form 10-K, Quarterly Reports on Form 10-Q, Current Reports on Form 8-K and all amendments to those reports as soon as reasonably practicable after electronically filed with or furnished to the SEC.

The information contained on our website is not a part of, and should not be construed as being incorporated by reference, into this report.

The reports filed with the SEC by us and by our officers, directors and significant stockholders are available for review on the SEC's website at www.sec.gov.

Item 1A. Risk Factors

You should carefully consider the following risk factors, together with all other information in this report, including our consolidated financial statements and notes thereto, and in our other filings with the SEC. If any of the following risks, or other risks not presently known to us or that we currently believe to not be material, develop into actual events, then our business, financial condition, results of operations or prospects could be materially adversely affected. If that happens, the market price of our common stock could decline, and stockholders may lose all or part of their investment.

Risks Related to Our Business

We have no approved products and depend on the future success of the product candidates in our research and development pipeline. We cannot be certain that we or our collaborators will be able to obtain regulatory approval for, or successfully commercialize, product candidates from our current pipeline or any other product candidates that we may subsequently identify, license or otherwise acquire.

We and our collaborators are not permitted to market or promote any products in the United States, Europe, China or other countries before we receive regulatory approval from the FDA or comparable foreign regulatory authorities, and we may never receive such regulatory approval for our current product candidates. We have not submitted a new drug application (NDA) to the FDA or comparable applications to other regulatory authorities and do not expect to be in a position to do so in the near future.

All of our product candidates are in clinical development or in varying stages of nonclinical development. Data supporting our drug discovery and nonclinical and clinical development programs are derived from laboratory studies, nonclinical studies and Phase 1 and Phase 2 clinical studies. It may be years before the larger, pivotal studies necessary to support regulatory approval of our current product candidates are completed, if ever.

In addition to our current product pipeline, we may identify, license or otherwise acquire rights to other technologies or product candidates. Any such transactions would involve numerous risks, and we may be unsuccessful in entering into any such transactions or developing any such technologies or product candidates.

For these reasons, our drug discovery and development may not be successful, and we may be unable to continue clinical development of our product candidates and may not generate product approvals or product revenue, any of which could have a material adverse impact on our business, results of operations and financial condition.

We are not currently profitable and might never become profitable, and we will need additional financing to complete the development of any product candidates and fund our activities into the future.

We do not have any approved products, and we have a history of losses. We expect to continue to incur substantial operating and capital expenditures to advance our current product candidates through clinical development, continue research and discovery efforts to identify potential additional product candidates and seek regulatory approvals for our current and future product candidates. All operations and capital expenditures will be funded from cash on hand, securities offerings, debt financings and payments we may receive from out-licenses, collaborations or other strategic arrangements. Elevated worldwide inflation rates that began in mid-2021 and continue to persist may also exacerbate the substantial operating and capital expenditures that we face to advance our current and future product candidates.

There is no assurance that we will be successful in raising any necessary additional capital on terms that are acceptable to us, or at all, particularly due the well-documented, ongoing sector-wide weakness in the biotech markets that began in early 2021. If we are unable to develop and commercialize any product candidates and generate sufficient revenue or raise capital, we could be forced to delay, scale back or discontinue product development and clinical studies, sacrifice attractive business opportunities, cease operations entirely and sell, or otherwise transfer, all or substantially all of our remaining assets, which would likely have a material adverse impact on our business, results of operations, financial condition and share price.

Nonclinical and clinical studies required for our product candidates are expensive and time-consuming and may fail to demonstrate the level of safety and efficacy necessary for product approval.

Before we or any commercial partners can obtain FDA approval (or other foreign approvals) necessary to sell any of our product candidates, we must show that each potential product is safe and effective. To meet these requirements, we must conduct extensive nonclinical and sufficient, well-controlled clinical studies.

The results of nonclinical studies may not be representative of disease behavior in a clinical setting and may not be predictive of the outcomes of our clinical studies. In addition, the results of early clinical studies of product candidates may not be predictive of the results of later-stage clinical studies.

Conducting nonclinical and clinical studies is a lengthy, time consuming and expensive process. The length of time varies substantially according to the type, complexity, novelty, and intended use of the product candidate, and often can be several years or more. In addition, failure or delays can occur at any time during the nonclinical and clinical study process, resulting in additional operating expenses or harm to our business.

The commencement and rate of completion of clinical studies might be delayed by many factors, including, for example:

- delays in reaching agreement with regulatory authorities on study design;
- delays in reaching agreement on acceptable terms with prospective CROs and clinical study sites;
- failure to demonstrate efficacy or the emergence of unforeseen safety issues;
- insufficient quantities of qualified materials under current good manufacturing practice (cGMP) for use in clinical studies due to manufacturing challenges, delays or interruptions in the supply chain;
- slower than expected rates of patient recruitment or failure to recruit a sufficient number of eligible patients, which may be due to a number of reasons, including the size of the patient population, the proximity of patients to clinical sites, the eligibility criteria for the study, the design of the clinical study, and other potential drug candidates being studied;
- delays in patients completing participation in a study or return for post-treatment follow-up for any reason, including, product side effects or disease progression;
- modification of clinical study protocols;
- delays, suspension, or termination of clinical studies by the institutional review board or ethics committee responsible for overseeing the study at a particular study site; and
- government or other regulatory agency delays or clinical holds requiring suspension or termination of our clinical studies due to safety, tolerability or other issues related to our product candidates.

The failure of nonclinical and clinical studies to demonstrate safety and effectiveness of a product candidate for the desired indications, whether conducted by us or by a CRO, would harm the development of that product candidate and potentially other product candidates. This failure could cause us to abandon a product candidate and could delay development of other product candidates. Any delay in, or failure of, our nonclinical studies or clinical studies could delay, or preclude, the filing of our NDAs and comparable applications with the FDA and foreign regulatory agencies, as applicable, and materially harm our business, prospects, financial condition and results of operations.

We rely on CROs to conduct some of our nonclinical and clinical studies due to our lack of suitable facilities and resources. In addition, parts of our business are reliant on CROs, vendors, suppliers and other service providers that are located outside of the United States.

We do not have sufficient facilities or resources to conduct all of our anticipated nonclinical and clinical studies internally. As a result, we contract with CROs to conduct a significant portion of the nonclinical and clinical studies required for regulatory approval for our product candidates. Our reliance on CROs reduces our control over these activities but does not relieve us of our responsibilities. For example, we are responsible for ensuring that each of our

studies is conducted in accordance with the applicable protocol, legal and regulatory requirements and scientific standards, including, in the case of clinical studies, good clinical practices, even if the study is conducted by a CRO. In the event CROs fail to perform their duties in such a fashion or we are unable to retain or continue with CROs on acceptable terms, we may be unable to complete our clinical studies and may fail to obtain regulatory approval for our product candidates.

In addition, these CROs may also have relationships with other entities, some of which may be our competitors. CRO personnel are not our employees, and except for remedies available to us under our agreements with such third parties, we cannot control whether they devote sufficient time and resources to our clinical and nonclinical studies. If these CROs do not successfully carry out their contractual duties or obligations or meet expected deadlines, if they need to be replaced or if the quality or accuracy of the clinical data they obtain is compromised due to the failure to adhere to our clinical protocols, regulatory requirements or for other reasons, our research, nonclinical or clinical studies may be extended, delayed or terminated and we may not be able to obtain, or may be delayed in obtaining, regulatory approvals for our product candidates, any of which could materially harm our business, prospects, financial condition and results of operations.

Furthermore, we are exposed to a number of risks related to our CROs, vendors, suppliers and other service providers that are located outside of the United States, many of which may be beyond our control. These risks include:

- business interruptions resulting from geopolitical actions such as Russia's invasion of Ukraine and the resulting war, as well as tariffs, other wars, acts of terrorism, natural disasters or outbreaks of disease;
- different regulatory requirements for drug approvals in foreign countries;
- different standards of care in various countries that could complicate the evaluation of our product candidates;
- different U.S. and foreign drug import and export rules;
- different reimbursement systems and different competitive drugs indicated to treat the indication for which our product candidates are being developed;
- reduced protection for intellectual property rights in certain countries;
- unexpected changes in tariffs, trade barriers and regulatory requirements;
- compliance with the United States Foreign Corrupt Practices Act (the FCPA) and other anti-corruption and anti-bribery laws;
- compliance with tax, employment, immigration and labor laws for employees living or traveling abroad;
- foreign taxes, including withholding of payroll taxes; and
- foreign currency fluctuations and compliance with foreign currency exchange rules, which could result in increased operating expenses and reduced revenues, and other obligations incident to doing business in another country.

Top-line or preliminary data may not accurately reflect the final results of a particular study.

We may publicly disclose top-line or preliminary data based on analysis of then-available efficacy, tolerability, PK and safety data, and the results and related findings and conclusions are subject to change following a more comprehensive review of the data related to the particular study. We also make assumptions, estimates, calculations and conclusions as part of our data analyses, and we may not have received or had the opportunity to fully and carefully evaluate all data prior to release. As a result, the top-line or preliminary results that we report may differ from final results of the same studies or different conclusions or considerations may qualify such results once additional data have been received and fully evaluated. Top-line data also remains subject to audit and verification procedures that may result in the final data differing materially from previously published preliminary data. As a result, top-line and preliminary data should be viewed with caution until the final data are available.

In addition to top-line or preliminary results, the information that we may publicly disclose regarding a particular nonclinical or clinical study is based on extensive information, and you or others may not agree with what we

determine is the material or otherwise appropriate information to include in our disclosure. In addition, any information we determine not to disclose may ultimately be deemed significant with respect to future decisions, conclusions, views, activities or otherwise regarding a particular drug, drug candidate or our business. If the top-line or preliminary data that we report differ from final results, or if others, including regulatory authorities, disagree with, or do not accept, the data or conclusions reached, our ability to obtain approval for, and commercialize, our product candidates may be harmed or delayed, which could harm our business, financial condition, operating results or prospects.

We rely on third parties to formulate and manufacture our product candidates and products that we study in combination with our product candidates. Our use of third parties may increase the risk that we will not have sufficient quantities of our product candidates or other products on time or at an acceptable cost.

We rely on third-party manufacturers to supply the quantities of our investigational product candidates used in our clinical and nonclinical studies. If any product candidate we develop or acquire in the future receives FDA or other regulatory approval, we expect to continue our reliance on one or more third-party contractors to manufacture our products. If, for any reason, we are unable to rely on any third-party sources we have identified to manufacture our product candidates, we would need to identify and contract with additional or replacement third-party manufacturers to manufacture drug substance and drug product for nonclinical, clinical and commercial purposes. We may be unsuccessful in identifying additional or replacement third-party manufacturers, or in negotiating acceptable terms with any that we do identify. If we are unable to establish and maintain manufacturing capacity, the development and sales of our products and our financial performance may be materially and adversely affected.

We are exposed to the following risks with respect to the manufacture of our product candidates:

- We will need to identify manufacturers for commercial supply on acceptable terms, which we may be unable to do because the number of potential manufacturers is limited, and the FDA must evaluate and approve any new or replacement contractor.

- Any third-party manufacturers with whom we contract might be unable to formulate and manufacture our product candidates in the volume and quality required to meet our clinical and, if approved, commercial needs in a timely manner.

- Any third-party manufacturers with whom we contract might not perform as agreed or might not remain in the contract manufacturing business for the time required to supply our products.

- One or more of any third-party manufacturers with whom we contract could be foreign, which increases the risk of shipping delays and adds the risk of import restrictions.

- We do not have complete control over, and cannot ensure, any third-party manufacturers' compliance with cGMP and other government regulations and corresponding foreign requirements, including periodic FDA and state regulatory inspections.

- We may be required to obtain intellectual property rights from third parties to manufacture our product candidates, and if any third-party manufacturer makes improvements in the manufacturing process for our product candidates, we may not own, or may have to share, the intellectual property rights to the innovation.

- We may be required to share our trade secrets and know-how with third parties, increasing risk of misappropriation or disclosure of our intellectual property by or to third parties.

- When contracting with third-party manufacturers, we might compete with other companies for access to these manufacturers' facilities and might be subject to manufacturing delays if the manufacturers give other clients higher priority than we are given.

Each of these risks could delay our development efforts, nonclinical studies and clinical studies or the approval, if any, of our product candidates by the FDA or applicable non-U.S. regulatory authorities and the commercialization of our product candidates. This could result in higher costs or deprive us of potential product revenues and materially harm our business, financial condition and results of operations.

If we lose key management personnel and cannot recruit and retain similarly qualified replacements, our business may materially suffer.

We are highly dependent on the services of our executive officers. Our employment agreements with our executive officers do not ensure their retention. We do not currently maintain, nor do we intend to obtain in the future, "key person" life insurance that would compensate us in the event of the death or disability of any of the members of our management team. Our executive officers are critical to our success, and unanticipated loss of any of these key employees could have a material adverse impact on our business, financial condition and results of operations.

Our collaboration partners might delay, prevent or undermine the success of our product candidates.

Our operating and financial strategy for the development, nonclinical and clinical testing, manufacture and commercialization of drug candidates heavily depends on collaborating with corporations, academic institutions, licensors, licensees, and other parties. However, there can be no assurance that we will successfully establish or maintain these collaborations. If a collaboration is terminated, replacement collaborators might not be available on attractive terms, or at all.

The activities of any collaborator will not be within our control and might not be within our power to influence. There can be no assurance that any collaborator will perform its obligations to our satisfaction or at all, that we will derive any revenue or profits from these collaborations, or that any collaborator will not compete with us. If any collaboration is unsuccessful, we might require substantially greater capital to undertake development and marketing of our proposed products and might not be able to develop and market these products effectively, if at all. In addition, a lack of development and marketing collaborations might lead to significant delays in introducing proposed products into certain markets and/or reduced sales of proposed products in such markets.

We rely on data provided by third parties that has not been independently verified and could prove to be false, misleading, or incomplete.

We rely on third-party vendors, scientists, investigators and collaborators to provide us with significant data and other information related to our projects, nonclinical studies and clinical studies, and our business. If these third parties provide inaccurate, misleading, or incomplete data, our business, prospects, and results of operations could be materially adversely affected.

Significant disruptions of information technology systems or breaches of data security could materially and adversely affect our business, results of operations and financial condition.

We collect and maintain information in digital form and are increasingly dependent on information technology systems and infrastructure to operate our business. In the ordinary course of our business, we collect, store and transmit large amounts of confidential information, including intellectual property, proprietary business information and personal information. It is critical that we do so in a secure manner to maintain the confidentiality and integrity of such confidential information. We have outsourced elements of our information technology infrastructure and, as a result, a number of third-party vendors may or could have access to our confidential information. Our internal information technology systems and infrastructure, and those of our current and any future collaborators, contractors and consultants and other third parties on which we rely, are vulnerable to damage from computer viruses, malware, natural disasters, terrorism, war, telecommunication and electrical failures, cyberattacks or cyber intrusions over the Internet, attachments to emails, persons inside our organization, or persons with access to systems inside our organization.

The risk of a security breach or disruption, particularly through cyberattacks or cyber intrusion, has escalated as the number, intensity and sophistication of attempted attacks and intrusions from around the world have increased. In addition, the prevalent use of mobile devices that access confidential information increases the risk of data security breaches, which could lead to the loss of confidential information or other intellectual property. The costs to us to mitigate network security problems, bugs, viruses, worms, malicious software programs and security vulnerabilities could be significant, and our efforts to address these problems may not be successful. If unsuccessful, these problems could cause interruptions, delays, cessation of service and other harm to our business and our competitive position, including material disruption of our product development programs. For example, any loss of clinical study data from completed or ongoing or planned clinical studies could result in delays in our regulatory approval efforts and significantly increase our costs to recover or reproduce the data.

If a computer security breach affects our systems or results in the unauthorized release of personally identifiable information, our reputation could be materially damaged. In addition, such a breach may require notification to governmental agencies, the media or individuals pursuant to various federal, state and non-U.S. privacy and security laws, if applicable, including the Health Insurance Portability and Accountability Act of 1996 (HIPAA), as amended by the Health Information Technology for Clinical Health Act of 2009, and its implementing rules and regulations, as well as regulations promulgated by the Federal Trade Commission, state breach notification law and the General Data Protection Regulation (GDPR) in the European Union (EU). We would also be exposed to a risk of loss or litigation and potential liability, which could materially adversely affect our business, results of operations and financial condition.

Research, development and commercialization goals may not be achieved in the timeframes that we publicly estimate, which could have an adverse impact on our business and could cause our stock price to decline.

We set goals, and make public statements regarding our expectations, regarding the timing of certain accomplishments, developments and milestones under our research and development programs. The actual timing of these events can vary significantly due to a number of factors, including, the amount of time, effort and resources committed to our programs by us and any collaborators and the uncertainties inherent in the clinical development and regulatory approval process. As a result, there can be no assurance that we or any collaborators will initiate or complete clinical development activities, make regulatory submissions or receive regulatory approvals as planned or that we or any collaborators will be able to adhere to our current schedule for the achievement of key milestones under any of our programs. If we or any collaborators fail to achieve one or more of the milestones as planned, our business could be materially adversely affected, and the price of our common stock could decline.

Developments by competitors might render our product candidates or technologies obsolete or non-competitive.

The pharmaceutical and biotechnology industries are intensely competitive. In addition, the clinical and commercial landscapes for HBV, HDV, high-recurrence genital herpes and transplant-related herpesviruses are rapidly changing; we expect new data from commercial and clinical-stage products to continue to emerge. We compete with organizations, some with significantly more resources, who are developing competitive product candidates. If our competitors develop effective treatments for HBV, HDV, high-recurrence genital herpes and transplant-related herpesviruses or any other indication or field we might pursue, and successfully commercialize those treatments, our business and prospects could be materially harmed.

Other companies with products using the same or similar mechanisms of action as ours may produce negative clinical data, which would adversely affect public and clinical communities' perceptions of our product candidates, and may negatively impact regulatory approval of, or demand for, our potential products.

Negative data from clinical studies using a competitor's product candidates with the same or similar mechanisms of action as ours could adversely impact the perception of the therapeutic use of our product candidates and our ability to enroll patients in clinical studies.

The clinical and commercial success of our potential products will depend in part on the public and clinical communities' acceptance of CIs, a novel class of product candidates. Moreover, our success depends upon physicians prescribing, and their patients being willing to receive, treatments that involve the use of our product candidates we may develop in lieu of, or in addition to, existing treatments with which they are already familiar and for which more clinical data may be available. Adverse events in our nonclinical or clinical studies or those of our competitors or of academic researchers utilizing the same mechanisms of action as our product candidates, even if not ultimately attributable to our product candidates, and any resulting publicity could result in increased governmental regulation, unfavorable public perception, potential regulatory delays in the testing or approval of our product candidates, stricter labeling requirements for our product candidates that are approved, if any, and a decrease in demand for any such products.

Risks Related to Our Regulatory and Legal Environment

We are and will be subject to extensive and costly government regulation and the failure to comply with these regulations may have a material adverse effect on our operations and business.

Our product candidates are subject to extensive and rigorous domestic government regulation including regulation by the FDA, the Centers for Medicare and Medicaid Services, other divisions of the U.S. Department of Health and

Human Services, the U.S. Department of Justice, state and local governments, and their respective foreign equivalents. Both before and after approval of any product, we and our collaborators, suppliers, contract manufacturers and clinical investigators are subject to extensive regulation by governmental authorities in the United States and other countries, covering, among other things, testing, manufacturing, quality control, clinical studies, post-marketing studies, labeling, advertising, promotion, distribution, import and export, governmental pricing, price reporting and rebate requirements. Failure to comply with applicable requirements could result in one or more of the following actions: warning or untitled letters; unanticipated expenditures; delays in approval or refusal to approve a product candidate; voluntary or mandatory product recall; product seizure; interruption of manufacturing or clinical studies; operating or marketing restrictions; injunctions; criminal prosecution and civil or criminal penalties including fines and other monetary penalties; exclusion from federal health care programs such as Medicare and Medicaid; adverse publicity; and disruptions to our business.

If we or our collaborators obtain regulatory approval for a particular product, the approval might limit the intended medical uses for the product, limit our ability to promote, sell, and distribute the product, require that we conduct costly post-marketing surveillance, and/or require that we conduct ongoing post-marketing studies. Once obtained, any approvals might be withdrawn, including, for example, if there is a later discovery of previously unknown problems with the product, such as a previously unknown safety issue.

If we, our collaborators, or our contract manufacturers fail to comply with applicable regulatory requirements at any stage during the regulatory process, such noncompliance could result in delays in the approval of applications or supplements to approved applications, refusal by a regulatory authority (including the FDA) to review pending market approval applications or supplements to approved applications, untitled letters or warning letters, fines, import and export restrictions, product recalls or seizures, injunctions, total or partial suspension of production, civil penalties, withdrawals of previously approved marketing applications, recommendations by the FDA or other regulatory authorities against governmental contracts, and/or criminal prosecutions.

The regulatory approval processes of the FDA and comparable foreign authorities are lengthy, time consuming and inherently unpredictable, and if we or our collaborators are ultimately unable to obtain regulatory approval for our product candidates, our business will be substantially harmed.

We, or any current or future collaborators, cannot assure you that we will receive the approvals necessary to commercialize for sale any of our product candidates, or any product candidate we acquire or develop in the future. We will need FDA approval to commercialize our product candidates in the United States and approvals from applicable regulatory authorities in foreign jurisdictions to commercialize our product candidates in those jurisdictions. To obtain FDA approval of any product candidate, we must submit to the FDA an NDA demonstrating that the product candidate is safe and effective for its intended use. This requires significant research, nonclinical studies, and clinical studies. Satisfaction of the FDA's regulatory requirements typically takes many years, depends upon the type, complexity and novelty of the product candidate and requires substantial resources for research, development and testing. We cannot predict whether our research and clinical approaches will result in drugs that the FDA considers safe and effective for their indicated uses. The FDA has substantial discretion in the approval process and might require us to conduct additional nonclinical and clinical testing, perform post-marketing studies or otherwise limit or impose conditions on any approval we obtain.

The approval process might also be delayed by changes in government regulation, future legislation or administrative action or changes in FDA policy that occur prior to or during our regulatory review. Delays in obtaining regulatory approvals might: delay commercialization of, and our ability to derive product revenues from, our product candidates; impose costly procedures on us; and diminish any competitive advantages that we might otherwise enjoy.

Even if we comply with all FDA requests, the FDA might ultimately reject one or more of our NDAs. We cannot be sure that we will ever obtain regulatory approval and commercialize any of our current or future product candidates. In foreign jurisdictions, we are subject to regulatory approval processes and risks similar to those associated with the FDA described above. We cannot assure you that we will receive the approvals necessary to commercialize our product candidates for sale outside the United States.

We and our collaborators may be subject, directly or indirectly, to applicable U.S. federal and state anti-kickback, false claims laws, physician payment transparency laws, fraud and abuse laws or similar healthcare and security

laws and regulations, and health information privacy and security laws, which could expose us or them to criminal sanctions, civil penalties, contractual damages, reputational harm and diminished profits and future earnings.

Healthcare providers, physicians and others play a primary role in the recommendation and prescription of any products for which we obtain regulatory approval. If we obtain FDA approval for any of our drug candidates and begin commercializing those drugs in the United States, our operations may be subject to various federal and state fraud and abuse laws, including the federal Anti-Kickback Statute, the federal False Claims Act, and physician payment sunshine laws and regulations. Additionally, we are subject to state and non-U.S. equivalents of each of the healthcare laws described above, among others, some of which may be broader in scope and may apply regardless of the payor. These laws may impact, among other things, our proposed sales, marketing and education programs. In addition, we may be subject to patient privacy regulation by both the federal government and the states and foreign jurisdictions in which we conduct our business. If we fail to comply with any applicable federal, state or foreign legal requirement, we could be subject to penalties.

Regulators globally are imposing greater monetary fines for privacy violations. The GDPR applies to any company established in the EU as well as to those outside the EU if they collect and use personal data in connection with the offering goods or services to individuals in the EU or the monitoring of their behavior. The GDPR enhances data protection obligations for processors and controllers of personal data, including, for example, expanded disclosures about how personal information is to be used, limitations on retention of information, mandatory data breach notification requirements and onerous new obligations on services providers. Noncompliance with the GDPR may result in monetary penalties of up to €20 million or 4% of worldwide revenue, whichever is higher. The GDPR may increase our responsibility and liability in relation to personal data that we process and we may be required to put in place additional mechanisms to ensure compliance with the GDPR, including as implemented by individual countries. Compliance with the GDPR and other changes in laws or regulations associated with the enhanced protection of certain types of personal data, such as healthcare data or other sensitive information, could greatly increase our cost of developing our products or even prevent us from offering certain products in jurisdictions that we may operate in.

The California Consumer Privacy Act (CCPA) also created new individual privacy rights for California consumers (as defined in the law) and places increased privacy and security obligations on entities handling personal data of consumers or households. The CCPA requires covered companies to provide certain disclosures to consumers about its data collection, use and sharing practices, and to provide affected California residents with ways to opt-out of certain sales or transfers of personal information. While there is currently an exception for protected health information that is subject to HIPAA and clinical study regulations, as currently written, the CCPA may impact our business activities. The uncertainty surrounding the implementation of the CCPA exemplifies the vulnerability of our business to the evolving regulatory environment related to personal data and protected health information.

Because of the breadth of these laws and the narrowness of the statutory exceptions and safe harbors available, it is possible that some of our business activities could be subject to challenge under one or more of such laws.

Violations of these laws may be punishable by criminal and/or civil sanctions, including penalties, fines and/or exclusion or suspension from federal and state healthcare programs such as Medicare and Medicaid and debarment from contracting with the U.S. government. In addition, private individuals have the ability to bring actions on behalf of the U.S. government under the federal False Claims Act as well as under the false claims laws of several states.

If any of the physicians or other providers or entities with whom we expect to do business with are found to be not in compliance with applicable laws, they may be subject to criminal, civil or administrative sanctions, including exclusions from government funded healthcare programs, which may also adversely affect our business.

We face the risk of product liability claims and might not be able to obtain insurance.

Our business exposes us to the risk of product liability claims that are inherent in drug development. If the use of one or more of our product candidates or approved drugs, if any, harms people, we might be subject to costly and damaging product liability claims brought against us by clinical study participants, consumers, health care providers, pharmaceutical companies or others selling our products. Our inability to obtain sufficient product liability/clinical study insurance at an acceptable cost to protect against potential product liability claims could prevent or inhibit the commercialization of pharmaceutical products we develop. We cannot predict all of the possible harms or side effects that might result and, therefore, the amount of insurance coverage we maintain might not be adequate to cover all

liabilities we might incur. If we are unable to obtain insurance at an acceptable cost or otherwise protect against potential product liability claims, we will be exposed to significant liabilities, which might materially and adversely affect our business and financial position. If we are sued for any injury allegedly caused by our products, our liability could exceed our total assets and our ability to pay. Any successful product liability claims brought against us would decrease our cash and may adversely affect our business, stock price and financial condition.

We might be exposed to liability claims associated with the use of hazardous materials and chemicals.

Our research, development and manufacturing activities and/or those of our third-party contractors might involve the controlled use of hazardous materials and chemicals. Although we will strive to have our safety procedures, and those of our contractors, comply with federal, state and local laws and regulations for using, storing, handling and disposing of these materials, we cannot completely eliminate the risk of accidental injury or contamination from these materials. In the event of such an accident, we could be held liable for any resulting damages, and any liability could materially and adversely affect our business, financial condition and results of operations. In addition, the federal, state and local laws and regulations governing the use, manufacture, storage, handling and disposal of hazardous or radioactive materials and waste products might require us to incur substantial compliance costs that could materially and adversely affect our business, financial condition and results of operations. We do not carry hazardous materials liability insurance. We intend to obtain such insurance in the future, if necessary, but cannot give assurance that we will obtain such coverage.

Our employees, independent contractors, consultants, collaborators and CROs may engage in misconduct or other improper activities, including noncompliance with regulatory standards and requirements, which could result in significant liability for us and harm our reputation.

We are exposed to the risk of fraud or other misconduct, including failure to:

- comply with applicable regulations of, and provide accurate information to, the FDA or comparable foreign regulatory authorities;
- comply with federal and state healthcare fraud and abuse laws and regulations and similar laws and regulations established and enforced by comparable foreign regulatory authorities;
- comply with the FCPA, the U.K. Bribery Act 2010, the PRC Criminal Law, the PRC Anti-unfair Competition Law and other anti-bribery and trade laws;
- report financial information and data accurately; or
- disclose unauthorized activities.

Misconduct could also involve the improper use or misrepresentation of information obtained during clinical studies, creating fraudulent data in our nonclinical studies or clinical studies or illegal misappropriation of product materials, which could result in regulatory sanctions, delays in clinical studies, or serious harm to our reputation.

It is not always possible to identify and deter misconduct. The precautions we take to detect and prevent this activity may not be effective in controlling unknown or unmanaged risks or losses or in protecting us from governmental investigations or other actions or lawsuits stemming from a failure to comply with such laws or regulations. Additionally, we are subject to the risk that a person or government could allege such fraud or other misconduct, even if none occurred. If any such actions are instituted against us and we are not successful in defending ourselves or asserting our rights, those actions could harm our business, results of operations, financial condition and cash flows, including through the imposition of significant fines or other sanctions.

Risks Related to Our Intellectual Property

Our business depends on protecting our intellectual property.

If we and our licensors do not obtain protection for our respective intellectual property rights, our competitors might be able to take advantage of our research and development efforts to develop competing drugs. Our success, competitive position and future revenues, if any, depend in part on our ability and the abilities of our licensors to obtain and maintain patent protection for our products, methods, processes and other technologies, to preserve our trade secrets, to prevent third parties from infringing on our proprietary rights and to operate without infringing the proprietary rights of third parties.

We rely upon a combination of patents, trade secret protection and contractual arrangements to protect the intellectual property related to our technologies. We will only be able to protect our products and proprietary information and technology by preventing unauthorized use by third parties to the extent that our patents, trade secrets, and contractual position allow us to do so. We cannot be certain that we will secure any rights to any issued patents with claims that cover any of our proprietary product candidates and technologies. The patent prosecution process is expensive and time-consuming, and we may be unable to file and prosecute all necessary or desirable patent applications at a reasonable cost or in a timely manner. We could fail to identify patentable aspects of our research and development output before it is too late to obtain patent protection or before our competitors secure patents covering such discoveries. The patent process also is subject to numerous risks and uncertainties, and there can be no assurance that we will be successful in protecting our products by obtaining and defending patents.

Composition-of-matter patents relating to the active pharmaceutical ingredient are generally considered to be the strongest form of intellectual property protection for pharmaceutical products. Such patents provide protection not limited to any one method of use. Method-of-use patents protect the use of a product for the specified method(s) and do not prevent a competitor from making and marketing a product that is identical to our product for an indication that is outside the scope of the patented method. We rely on a combination of these and other types of patents to protect our product candidates, and there can be no assurance that our intellectual property will create and sustain the competitive position of our product candidates.

Biotechnology and pharmaceutical product patents involve highly complex legal and scientific questions. Any patent applications that we own or license may fail to result in issued patents. In addition, the U.S. Patent and Trademark Office (USPTO) and patent offices in other jurisdictions often require that patent applications concerning pharmaceutical and/or biotechnology-related inventions are limited or narrowed substantially to cover only the specific innovations exemplified in the patent application, thereby limiting the scope of protection against competitive challenges. As a result, even if we or our licensors obtain patents, the patents might be substantially narrower than anticipated.

If patents do successfully issue from our applications, third parties may challenge their validity or enforceability, which may result in such patents being narrowed, invalidated, or held unenforceable. Even if our patents and patent applications are not challenged by third parties, those patents and patent applications may not prevent others from designing around our claims and may not otherwise adequately protect our product candidates.

Patent and other intellectual property protection is crucial to the success of our business and prospects, and there is a substantial risk that such protections, if obtained, will prove inadequate. The legal systems of certain countries, including China, do not always favor the enforcement of patents, trade secrets, and other intellectual property rights, particularly those relating to pharmaceutical and biotechnology products, which could make it difficult for us to stop infringement of our patents, misappropriation of our trade secrets, or marketing of competing products in violation of our proprietary rights.

Beyond the protection afforded by patents, we seek to rely on trade secret protection and confidentiality agreements to protect proprietary know-how, information, or technology that is not covered by our patents. Although our agreements require all of our employees to assign their inventions to us, and we require all of our employees, consultants, advisors, collaborators, contractors and any third parties who have access to our trade secrets, proprietary know-how and other confidential information and technology to enter into appropriate confidentiality agreements, we cannot be certain that our trade secrets, proprietary know-how and other confidential information and technology will not be subject to unauthorized disclosure or that our competitors will not otherwise gain access to or independently

develop substantially equivalent trade secrets, proprietary know-how and other information and technology. If we are unable to prevent unauthorized disclosure of our intellectual property related to our product candidates and technology to third parties, we may not be able to establish or maintain a competitive advantage in our market, which could materially adversely affect our business and operations.

We may incur substantial costs as a result of litigation or other proceedings relating to our patents and other intellectual property rights.

We may in the future be involved in legal or administrative proceedings involving our intellectual property, including infringement of our intellectual property by third parties. These lawsuits or proceedings likely would be expensive, consume time and resources and divert the attention of managerial and scientific personnel, even if we were successful in stopping the infringement of such patents. There is a risk that these proceedings will decide that such patents or other intellectual property rights are not valid and that we do not have the right to stop the other party from using our inventions. There is also the risk that, even if the validity of such patents is upheld, the court or administrative agency will refuse to stop the other party on the ground that such other party's activities do not infringe our rights to such patents. If we were not successful in defending our intellectual property, our competitors could develop and market products based on our discoveries, which may reduce demand for our products.

We may infringe the intellectual property rights of others, which may prevent or delay our product development efforts and stop us from commercializing or increase the costs of commercializing our product candidates.

Our success will depend in part on our ability to operate without infringing the proprietary rights of third parties. Our competitors may have filed, and may in the future file, patent applications covering products and technologies similar to ours. Any such patent application may have priority over our patent applications, which could further require us to obtain rights from third parties to issued patents covering such products and technologies. We cannot guarantee that the manufacture, use or marketing of any product candidates that we develop will not infringe third-party patents.

If a patent infringement suit were brought against us, we may be forced to stop or delay developing, manufacturing, or selling potential products that are claimed to infringe a third party's intellectual property, unless that third party grants us rights to use its intellectual property. In such cases, we may be required to obtain licenses to patents or proprietary rights of others to continue development, manufacture or sale of our products. If we are unable to obtain a license or develop or obtain non-infringing technology, or if we fail to defend an infringement action successfully, or if we are found to have infringed a valid patent, we may incur substantial costs and monetary damages, encounter significant delays in bringing our product candidates to market and be precluded from manufacturing or selling our product candidates, any of which could harm our business significantly.

The cost of maintaining our patent protection globally is high and requires continuous review and compliance. We may not be able to effectively maintain our intellectual property position throughout the major markets of the world.

The USPTO and foreign patent authorities require maintenance fees, payments and continued compliance with a number of procedural and documentary requirements. Noncompliance may result in abandonment or lapse of patents or patent applications and a partial or complete loss of patent rights in the relevant jurisdiction. Such a loss could reduce royalty payments for lack of patent coverage from our collaboration partners or may result in competition, either of which could have a material adverse effect on our business.

We have made, and will continue to make, certain strategic decisions in balancing the costs and the potential protections afforded by the patent laws of certain countries. As a result, we may not be able to prevent third parties from practicing our inventions in all countries, or from selling or importing products made using our inventions in and into the United States or other countries. Third parties may use our technologies in territories in which we have not obtained patent protection to develop their own products and may infringe our patents in territories which provide inadequate enforcement mechanisms. Such third-party products may compete with our product candidates, and our patents or other intellectual property rights may not be effective or sufficient to prevent them from competing. Such competition could materially and adversely affect our business and financial condition.

Intellectual property rights do not address all potential threats to any competitive advantage we may have.

The degree of future protection afforded by our intellectual property rights is uncertain because intellectual property rights have limitations, and intellectual property rights may not adequately protect our business or permit us to maintain our competitive advantage. The following examples are illustrative:

- Others may be able to make compounds that are the same as, or similar to, our current or future product candidates but that are not covered by the claims of the patents that we own or have exclusively licensed.
- We or any of our licensors or strategic partners might not have been the first to make the inventions covered by the issued patents or pending patent applications that we own or have exclusively licensed.
- We or any of our licensors or strategic partners might not have been the first to file patent applications covering certain of our inventions.
- Others may independently develop similar or alternative technologies or duplicate any of our technologies without infringing our intellectual property rights.
- The prosecution of our pending patent applications may not result in granted patents.
- Granted patents that we own or have exclusively licensed may not provide us with any competitive advantages, or may be held invalid or unenforceable, because of legal challenges by our competitors.
- Patent protection on our product candidates may expire before we are able to develop and commercialize the product, or before we are able to recover our investment in the product.
- Our competitors might conduct research and development activities in the United States and other countries that provide a safe harbor from patent infringement claims for such activities, as well as in countries in which we do not have patent rights and may then use the information learned from such activities to develop competitive products for sale in markets where we intend to market our product candidates.

The existence of counterfeit pharmaceutical products in pharmaceutical markets may damage our brand and reputation and have a material adverse effect on our business, operations and prospects.

Counterfeit products, including counterfeit pharmaceutical products, are a significant problem, particularly in China. Counterfeit pharmaceuticals are products sold or used for research under the same or similar names, or similar mechanism of action or product class, but which are sold without proper licenses or approvals. The proliferation of counterfeit pharmaceuticals has grown in recent years and may continue to grow in the future. Such products may be used for indications or purposes that are not recommended or approved or for which there is no data or inadequate data with regard to safety or efficacy. Such products divert sales from genuine products, often are of lower cost and lower quality (having different ingredients or formulations, for example), and have the potential to damage the reputation for quality and effectiveness of the genuine product.

If counterfeit pharmaceuticals illegally sold or used for research result in adverse events or side effects to consumers, we may be associated with any negative publicity resulting from such incidents. In addition, counterfeit products could be used in nonclinical studies or clinical studies or could otherwise produce undesirable side effects or adverse events that may be attributed to our products as well, which could cause us or regulatory authorities to interrupt, delay or halt clinical studies and could result in the delay or denial of regulatory approval by the FDA or other regulatory authorities and potential product liability claims.

In China, although the government has increased the lower and upper limits on penalties on producers of counterfeit and substandard pharmaceuticals, these penalties have not eliminated counterfeit pharmaceuticals. As a result, we may be unable to prevent third parties from selling or purporting to sell our products in China. The existence of, and any increase in, the sales and production of counterfeit pharmaceuticals, or the technological capabilities of counterfeiters, could negatively impact our revenues, brand reputation, business and results of operations.

Risks Related to Our Common Stock

Our amended and restated bylaws provide that the Court of Chancery of the State of Delaware will be the sole and exclusive forum for certain types of actions and proceedings that may be initiated by our stockholders, which could limit our stockholders' ability to bring a claim in a judicial forum they find favorable for disputes with us or our directors, officers or other employees.

Our amended and restated bylaws provide that, with certain limited exceptions, unless we consent to the selection of an alternative forum, the Court of Chancery of the State of Delaware is the sole and exclusive forum for (1) any derivative action or proceeding brought on our behalf; (2) any action asserting a claim of breach of fiduciary duty owed by any of our current or former directors, officers or other employees to us or to our stockholders; (3) any action asserting a claim arising pursuant to the Delaware General Corporation Law, or our certificate of incorporation or bylaws (as each may be amended from time to time); or (4) any action asserting a claim governed by the internal affairs doctrine. Alternatively, if such court does not have jurisdiction, the Superior Court of Delaware, or, if such other court does not have jurisdiction, the United States District Court for the District of Delaware, will be the sole and exclusive forum for such actions and proceedings. The choice of forum provision may limit a stockholder's ability to bring a claim in a judicial forum that it finds favorable for disputes with us or our directors, officers, or other employees, which may discourage such lawsuits against us and our directors, officers, and other employees. Alternatively, if a court were to find the choice of forum provision contained in our amended and restated bylaws to be inapplicable or unenforceable in an action, we may incur additional costs associated with resolving such action in other jurisdictions, which could have a material adverse impact on our business. The choice of forum provision in our amended and restated bylaws will not preclude or contract the scope of exclusive federal or concurrent jurisdiction for actions brought under the federal securities laws, including the Exchange Act or the Securities Act, or the respective rules and regulations promulgated thereunder.

The price of our common stock might fluctuate significantly, and you could lose all or part of your investment.

The price of our common stock fluctuates widely. Continued volatility in the market price of our common stock might prevent a stockholder from being able to sell shares of our common stock at or above the price paid for such shares. The trading price of our common stock may continue to be volatile and subject to wide price fluctuations in response to various factors, many of which are beyond our control, such as the progress, results and timing of our clinical and nonclinical studies and other studies involving our product candidates, the success or failure of our product candidates, the receipt or loss of required regulatory approvals for our product candidates, the availability of capital or the other risks discussed in this "Risk Factors" section.

Item 1B. Unresolved Staff Comments

None.

Item 2. Properties

We lease office space for corporate and administrative functions and laboratory space in South San Francisco, California under a sub-sublease that expires in December 2023. We also lease office space that was used for administrative functions in Carmel, Indiana under a lease agreement that expires in August 2023. In February 2021, we subleased substantially all of the office space under the lease in Carmel, Indiana for the remainder of its term. Our China subsidiary leases registrational offices in Shanghai and Beijing. Our lease in Shanghai expires in November 2023, and our Beijing lease expired in October 2022 and has been extended on a month-to-month term.

We believe these leased facilities are adequate for our current needs and that additional space will be available in the future on commercially reasonable terms as needed.

Item 3. Legal Proceedings

We are not a party to any material legal proceedings at this time. From time to time, we may be subject to various legal proceedings and claims that arise in the ordinary course of our business activities. Although the results of litigation and claims cannot be predicted with certainty, we do not believe we are party to any claim or litigation the outcome of which, if determined adversely to us, would individually or in the aggregate be reasonably expected to have a material adverse effect on our business. Regardless of the outcome, litigation can have an adverse effect on us because of defense and settlement costs, diversion of management resources and other factors.

Item 4. Mine Safety Disclosures

Not applicable.

PART II

Item 5. Market for Registrant's Common Equity, Related Stockholder Matters and Issuer Purchases of Equity Securities

Market Information for Common Stock

Our common stock is traded under the symbol "ASMB" and is quoted on The Nasdaq Global Select Market.

Holders of Record

As of March 20, 2023, there were 76 stockholders of record, which excludes stockholders whose shares were held in nominee or street name by brokers.

Dividend Policy

We have never declared or paid any dividends and do not anticipate paying any dividends on our common stock in the foreseeable future.

Recent Sales of Unregistered Securities

There were no unregistered sales of equity securities in 2022.

Purchases of Equity Securities by the Issuer and Affiliated Purchasers

We did not purchase any of our registered equity securities during the period covered by this Annual Report on Form 10-K.

Item 6. [Reserved]

Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operation

The following discussion and analysis of our financial condition and results of operations should be read in conjunction with our consolidated financial statements and the related notes thereto and other financial information appearing elsewhere in this Annual Report on Form 10-K. The following discussion contains forward-looking statements that involve risks and uncertainties. Our actual results could differ materially from those expressed or implied in any forward-looking statements as a result of various factors, including those set forth in this Form 10-K under "Item 1A. Risk Factors."

Overview

We are a biopharmaceutical company advancing clinical candidates with the potential to improve the lives of millions of people living with chronic hepatitis B virus (HBV) infection around the world, an early-stage development program targeting high-recurrence genital herpes and research programs focused on the discovery of novel antivirals to treat devastating viral diseases, including hepatitis delta virus (HDV), herpes simplex virus type 2 (HSV-2) and transplant-related herpesviruses.

In July 2022, we implemented a strategic restructuring plan to: (1) discontinue development of our first-generation core inhibitor (CI), vebicorvir (VBR), based on review of interim on-treatment efficacy data from then ongoing triple combination studies that did not support continuation; (2) advance our next-generation CIs, ABI-H3733 (3733) and ABI-4334 (4334), in clinical studies; and (3) prioritize research activities, including our: HBV/HDV entry inhibitor; orally bioavailable, liver-focused interferon-α (IFN-α) receptor (IFNAR) agonist; long-acting HSV-2 helicase inhibitor targeting high-recurrence genital herpes; and programs targeting pan-herpes non-nucleoside polymerase inhibitors (NNPIs) for transplant-associated infections. The strategic plan included a reduction of our workforce by 30 employees, resulting in a total of approximately 70 remaining employees. In connection with the plan, our Chief Medical Officer and Chief Financial Officer stepped down from their roles.

Our HBV and HDV Programs

The World Health Organization (WHO) estimates that 296 million people worldwide are chronically infected with HBV as of 2019, and 1.5 million new infections occur each year. HBV is a leading global cause of chronic liver disease and liver transplants, and the WHO estimates that 820,000 people died in 2019 from HBV, mostly due to cirrhosis and hepatocellular carcinoma. Of the 296 million people living with chronic HBV infection as of 2019, only approximately 30 million were aware of their infection, and only approximately 6.6 million of those diagnosed received treatment. HBV is a highly prevalent disease that infects more than three times the number of people infected with hepatitis C virus and HIV infections combined, according to the WHO, and has a higher morbidity and mortality rate.

The current standard of care for chronic HBV infection, NrtIs, are taken life-long and reduce, but do not eliminate, the virus and result in very low cure rates, leaving an enormous unmet need. No new mechanisms of action (MOA) have been approved for chronic HBV infection in over 25 years. The focus of our HBV program is to improve outcomes and increase the number of patients diagnosed and treated through the development of finite and curative therapies.

We are also progressing two programs with potential application against HDV. HDV is a "satellite virus," because it can only infect people (1) who are already infected with HBV or (2) at the same time as a person is infected with HBV. HDV impacts a subset of approximately 12 million HBV patients. These patients, which only comprise an estimated 4.5% of hepatitis B surface antigen (HBsAg) positive patients, experience a substantially increased disease burden, as they account for 18% of cirrhosis and 20% of hepatocellular carcinoma associated with HBV. In parallel with our efforts to develop finite therapies and functional cures for HBV, we are also advancing programs targeting HDV given the immediate disease burden facing these patients.

The current standard of care treatment for HDV is off-label pegylated IFN-α injected weekly or, in some regions, a large, complex molecule that requires daily injections. We believe a safe and effective oral small molecule entry inhibitor would be a significant innovation for patients living with HDV.

Core Inhibitors

HBV is a DNA virus that infects hepatocytes and establishes a reservoir of covalently closed circular DNA (cccDNA), a unique viral DNA moiety that resides in the cell nucleus of HBV-infected hepatocytes and is associated with viral persistence and chronic infection. No currently approved oral therapies target cccDNA activity directly, which makes molecules that can modulate cccDNA generation or disrupt its function highly sought in the HBV field. As a result, we have worked to discover and develop compounds targeting the core protein, a viral protein involved in numerous aspects of the HBV replication cycle, including the generation of HBV cccDNA. Through our research efforts, we have discovered several chemically distinct series of small molecule CIs that directly target and allosterically inhibit core protein functions. As a result, we believe that our pipeline offers the potential for both first-in-class and best-in-class compounds that target critical steps involved in cccDNA generation and the HBV viral replication cycle.

A benchmark for therapeutic agents aiming to decrease cccDNA levels is the use of several key viral antigens as surrogate biomarkers of active cccDNA. The same biomarkers can be used in both primary human hepatocyte cells and patients. On this basis, our CIs have shown preclinical proof of principle. In a variety of cell culture models, CIs have demonstrated the ability to reduce production of viral HBV DNA levels as well as the surrogate markers for cccDNA establishment: HBV e antigen (HBeAg), HBV core-related antigen (HBcrAg) and viral pre-genomic RNA (pgRNA).

Our research and development organizations are advancing next-generation CIs through clinical development. These candidates, which exhibit multiple MOAs, have been optimized to potently disrupt both viral replication (MOA #1) and, importantly, prevent the establishment and replenishment of new cccDNA (MOA #2). cccDNA is the viral reservoir that drives HBV's life-long persistence in patients. First-generation CIs have not demonstrated adequate potency to sufficiently block its formation. Further, the current standard of care, NrtIs, can only inhibit production of new virus—and do so incompletely.

We leveraged our prior experience with our first-generation CI, VBR, which did not have sufficient potency against MOA #2, in the development of our next-generation CIs. VBR was evaluated in a Phase 2 program with treatment for up to 1.5 years across patient populations and exhibited a favorable safety profile. VBR was observed to be potent against MOA #1 but not MOA #2, and, while it demonstrated greater viral suppression in combination with standard-of-care NrtIs than NrtIs alone, it did not achieve functional cure or finite treatment in our clinical studies. As a result, we discontinued development of VBR. Our two next-generation CIs, 3733 and 4334, were developed to optimize activity against both MOAs and show significantly enhanced potency against both mechanisms preclinically.

3733

3733 was internally discovered and developed. The chemical scaffold of 3733 is novel and distinct from 4334 and both of our discontinued first-generation CI product candidates, VBR and ABI-H2158 (2158).

In preclinical studies, 3733 has demonstrated pan-genotypic activity and an improved resistance profile, as well as significantly increased potency against both MOAs and target coverage as compared to both VBR and 2158. In 2020, we initiated and completed a Phase 1a clinical study of 3733 to evaluate safety, tolerability and pharmacokinetics (PK) following single ascending dose and multiple ascending dose administration in healthy subjects in New Zealand. Data indicated that 3733 was generally well-tolerated and had favorable PK. Results detailing 3733's safety and PK from this study were presented in a poster presentation at the American Association for the Study of Liver Diseases (AASLD) The Liver Meeting® in November 2021 (AASLD 2021). In 2021, following the completion of the Phase 1a trial, our chemistry, manufacturing and controls (CMC) organization developed a new tablet formulation to support Phase 1b for 3733. At the European Association for the Study of the Liver's (EASL) International Liver Congress™ in June 2022 (EASL 2022), we presented 3733's improved PK profile resulting from the new formulation activities mentioned above.

In addition, at EASL's International Liver Congress™ in June 2021 (EASL 2021), we presented observations on 3733's enhanced potency and target coverage for both antiviral activity and inhibition of cccDNA generation as compared to VBR and 2158.

In June 2022, we initiated a randomized, multi-center, double-blind and placebo-controlled Phase 1b trial of 3733 evaluating the safety, PK and antiviral activity of 3733 in adults with cHBV infection, including changes in HBV DNA and other viral parameters associated with 3733 treatment in adults with chronic HBV infection who are

treatment naïve or off treatment. Patients were randomized 8:2 between the new tablet formulation of 3733 and placebo for a period of 28 days.

In December 2022, we released interim data from the Phase 1b trial, which consisted primarily of HBeAg negative patients. The dose selected for the first cohort was 50 mg. Given the potent antiviral activity observed at 50 mg, a 25 mg dose was selected for the second cohort to further explore the dose response curve of 3733. A dose of 100 mg was selected for the third cohort. As of mid-December 2022, dosing in the 3733 Phase 1b trial had been completed for all ten patients in the 50 mg first cohort. Nine of ten patients enrolled were HBeAg negative, so efficacy data was provided for these patients. Interim efficacy results from this cohort as of mid-December included HBV DNA, HBV RNA and antigen measurements for all patients for the full 28-day dosing period.

In the 50 mg cohort, six of eight patients receiving 3733 achieved HBV DNA less than the lower limit of quantification (<LLOQ) within 21 days, with a mean decline in HBV DNA over the treatment period of approximately 3.1 logs. Data on HBV RNA declines were limited due to low baseline levels in predominantly e-antigen negative patients.

The second cohort, evaluating a dose of 25 mg, was fully enrolled by December 2022. Nine of ten patients enrolled were HBeAg negative. In the five patients that had completed 28 days of treatment as of mid-December 2022, the mean reduction in HBV DNA was approximately 1.9 logs. Data on HBV RNA levels were not available as of mid-December 2022.

The third cohort, evaluating a dose of 100 mg, was fully enrolled by February 2023. Ten of 11 patients enrolled were HBeAg negative so efficacy data was provided for these patients. Interim efficacy results from this cohort as of mid-March included HBV DNA, HBV RNA, and antigen measurements for the seven HBeAg negative patients receiving 3733 that had completed 28 days of treatment. All seven patients achieved HBV DNA <LLOQ within 21 days. As all of these patients reached <LLOQ, the mean declines in HBV DNA over the treatment period of approximately 3.0 logs reflect baseline DNA levels and the lower limit of the quantifiable range in this cohort. Data on HBV RNA declines were limited due to low baseline levels in predominately HBeAg negative patients. As expected given the 28-day dosing period, limited changes in viral antigens were observed.

In the 25 mg, 50 mg and 100 mg cohorts, all treatment-emergent adverse events (AEs) and laboratory abnormalities reported were Grade 1 or Grade 2. Further, no AEs led to treatment discontinuation, and no clinically significant ECG abnormalities or patterns of AEs or lab abnormalities were noted. The observed PK for the new tablet formulation of 3733 was consistent with predictions from preclinical studies, providing exposure equivalent to the liquid formulation evaluated in the Phase 1a study for 3733. Available PK data indicated that exposures exhibited dose-proportional increases in the dose range from 25 mg to 100 mg.

As expected, given the 28-day dosing period, limited changes in viral antigens were observed.

A 26-week non-clinical chronic toxicology study of 3733 has been ongoing in parallel with the Phase 1b study. This study revealed a toxicity in one species that was not observed in the previous 28-day toxicology study. We continue to evaluate the data; however, proceeding with longer-term dosing of 3733 in a Phase 2 study would require further assessment and likely an additional chronic toxicology study in another species, which would add cost and time to the development timeline for 3733.

In March 2023, based on data to date from the ongoing clinical Phase 1 studies of both 3733 and 4334 and a non-clinical chronic toxicology study of 3733, we have paused core inhibitor candidate 3733 and prioritized core inhibitor candidate 4334.

4334

In mid-2021, we announced the selection of 4334, the second of our next-generation CI product candidates. As with all our CI product candidates nominated after VBR, 4334 was internally discovered and developed. In addition, the chemical scaffold of 4334 is also novel and distinct from VBR, which is licensed from Indiana University, 3733 and 2158.

We nominated 4334 based on a preclinical target drug profile that indicates enhanced target coverage and potency against both MOAs. We believe that 4334 has a best-in-class preclinical profile, with single-digit nanomolar potency

against the production of new virus and the formation of cccDNA. Preclinically to date, 4334 has also demonstrated pan-genotypic activity, an improved resistance profile and a favorable safety profile. Preclinical characterization of 4334 was shared in a poster presentation at AASLD in November 2021. At EASL 2022, we presented preclinical data demonstrating that 4334 promotes formation of empty capsids and prevents cccDNA formation by disrupting incoming capsids. At AASLD in November 2022 (AASLD 2022), we presented preclinical data demonstrating that 4334 also accelerates capsid assembly and inhibits cccDNA formation through multiple pathways and showed that 4334 can prematurely disrupt capsids containing dendrimer-like-DNA, which has the potential to impact HBV integration.

In October 2022, we initiated a Phase 1a clinical study of 4334 to evaluate safety, tolerability and PK following single ascending dose and multiple ascending dose administration in healthy subjects in New Zealand. We shared interim data from this Phase 1a trial at two time points, as of mid-December 2022 for the initial 30 mg single dose cohort and as of mid-March 2023 for all remaining single dose cohorts (100 mg, 200 mg and 400 mg) and the first 100 mg multiple-dose cohort. Dosing has completed for the second and final multiple dose cohort of 200 mg and a food effect cohort at 200 mg is also ongoing. We expect to share safety and PK data from this final multiple dose cohort when available in April 2023.

Based on data available for the single-dose and 100 mg multiple-dose cohorts as of mid-March 2023, 4334 had a mean half-life supporting once-a-day dosing. Based on the PK data from these cohorts and preclinical studies, daily minimum plasma trough concentrations (C_{min}) were projected to achieve double-digit multiples of the protein-adjusted EC_{50} for both MOAs within the dose ranges studied in the Phase 1a study.

Through mid-March 2023, treatment-emergent AEs and laboratory abnormalities were mild to moderate and there were no patterns of AEs or laboratory abnormalities noted and no clinically significant ECG abnormalities were reported.

In March 2023, based on data to date from the ongoing clinical Phase 1 studies of both 3733 and 4334 and a non-clinical chronic toxicology study of 3733, we have prioritized core inhibitor candidate 4334 and paused core inhibitor candidate 3733.

HBV/HDV Entry Inhibitor

In March 2022, we announced our research program focused on a novel, orally bioavailable small molecule approach to inhibit entry of HBV and HDV. While HDV is less prevalent in the United States, it is a significant and serious health problem with inadequate treatment in many parts of Europe, Africa, the Middle East, East Asia and parts of South America. HDV is known to accelerate disease progression and increase the incidence of liver cirrhosis and liver cancer, which results in higher morbidity and mortality rates than HBV alone. The current standard of care treatment for HDV is off-label pegylated IFN-α injected weekly or, in some regions, a large, complex molecule that requires daily injections. We believe a safe and effective oral small molecule entry inhibitor would be a significant innovation for patients living with HDV. Our research team has identified a potential opportunity to develop a safe and effective oral small molecule viral entry inhibitor, which could significantly improve convenience and potentially enhance treatment uptake and diagnosis rates. Based on current progress, our aim is to nominate a product candidate for development in 2023. At AASLD 2022, we presented the preclinical characterization of our novel class of highly potent small molecule HBV/HDV entry inhibitors.

IFNAR Agonist

In July 2022, we introduced our new research program advancing a novel, small molecule IFNAR agonist designed to selectively activate the IFN-α pathway within the liver and offer the convenience of oral dosing. IFN-α is a subcutaneous injectable immune modularity therapy approved for HBV that has demonstrated functional cure in some HBV patients, but its poor tolerability profile significantly limits its use. Substantial side effects include flu-like symptoms, cytopenias, serious depression and psychiatric effects. In addition, multiple contraindications limit its use, and it requires weekly injections that result in systemic exposure for up to a year.

By focusing exposure on the liver, our investigational IFNAR agonist program aims to engage interferon-α's validated antiviral and immune modulatory mechanisms, retaining the efficacy of IFN-α while reducing systemic exposure to improve tolerability. Lead optimization of multiple agonists is progress. At AASLD 2022, we presented the preclinical characterization of our novel liver-focused small molecule agonists efficiently inhibiting HBV by activating type 1 interferon signaling.

Our Herpesvirus Programs

In August 2022, in addition to announcing our HBV/HDV inhibitor and IFNAR agonist programs, we introduced our first programs outside of hepatitis, which target high-recurrence genital herpes and transplant-associated herpesviruses.

HSV-2

Up to 40% of symptomatic patients with HSV-2 suffer from high-recurrence genital herpes, which results in painful lesions occurring six or more times per year, transmission risk (including neonatal transmission) and increased risk of HIV infection, as well as associated psychological stress.

Helicase-primase inhibitors are antiviral agents with a novel mechanism of action. They inhibit the viral protein complex consisting of helicase, primase, and cofactor subunits, which have functions that are essential for viral DNA replication. These agents are not nucleoside analogues and do not require phosphorylation by the HSV thymidine kinase (TK) to become active drugs; therefore, helicase-primase inhibitors are active immediately upon reactivation of latent HSV. Furthermore, helicase-primase inhibitors are active against TK-deficient HSV, which is a major mechanism of resistance to nucleoside analogues.

Although there are approved antiviral therapies targeting HSV-2, these current therapies are only partially effective in preventing recurrence in patients experiencing high-recurrence genital herpes and require taking one or more pills daily. Due to the limitations of current therapies, we identified an opportunity to develop a potent, long-acting injectable helicase inhibitor with the potential to improve efficacy, convenience and patient compliance. We are targeting long-acting at least monthly dosing and will continue to evaluate longer dosing intervals as development and formulation progress.

In February 2023, we nominated a development candidate for our HSV-2 long-acting helicase inhibitor program, 5366, for progression into IND-enabling studies.

Transplant-Associated Herpesviruses

In a transplant setting, when patients are experiencing immunosuppression, they are at high risk of uncontrolled viral replication and severe disease brought on by one or more members of the herpesvirus family of viruses including cytomegalovirus (CMV), herpes simplex virus type 1, HSV-2 and varicella zoster virus (VZV). Each of these herpesviruses are highly prevalent, as approximately (1) 60% of the population is CMV-positive; (2) 60% of the population is HSV-positive; and (3) 80% of the population is VZV-positive. These viruses establish lifelong latent infections and frequently reactivate in transplant patients due to immune suppression. These uncontrolled viral infections increase risk of serious complications, including organ rejection and death.

As with HSV-2, there are approved antivirals that are administered in a transplant setting, but they are limited by a narrow spectrum (no approved drug is effective against all of the herpesviruses indicated above), potentially serious side effects and significant drug-drug interactions. As a result of these limitations, we identified an opportunity to develop an oral pan-herpes NNPI for these transplant-associated herpesvirus infections, which would greatly simplify treatment. Our research team has discovered multiple series of potent, broad-spectrum herpesvirus polymerase inhibitors.

Operations

We currently have corporate and administrative offices and research laboratory space in South San Francisco, California as well as registrational offices, but no employees, in China.

Since our inception, we have had no revenue from product sales and have funded our operations principally through debt financings prior to our initial public offering in 2010 and through equity financings and collaborations since then. Our operations to date have been primarily limited to organizing and staffing our company, licensing our product candidates, discovering and developing our product candidates, maintaining and improving our patent portfolio and raising capital.

We have generated significant losses to date, and we expect to continue to generate losses as we develop our product candidates. As of December 31, 2022, we had an accumulated deficit of $724.5 million. Because we do not generate revenue from any of our product candidates, our losses will continue as we further develop and seek regulatory approval for, and commercialize, our product candidates. As a result, our operating losses are likely to be substantial over the next several years as we continue the development of our product candidates and thereafter if none are

approved or successfully launched. We are unable to predict the extent of any future losses or when we will become profitable, if at all.

Critical Accounting Estimates

Our management's discussion and analysis of our financial condition and results of operations is based on our consolidated financial statements, which we have prepared in accordance with accounting principles generally accepted in the United States. The preparation of these consolidated financial statements requires us to make estimates and assumptions that affect the reported amounts of assets and liabilities and the disclosure of contingent assets and liabilities at the date of the financial statements, as well as the reported amounts of revenues and expenses during the reporting periods. Note 2 to the Consolidated Financial Statements describes the significant accounting policies and methods used in the preparation of our consolidated financial statements. We evaluate our estimates and judgments, including those described in greater detail below, on an ongoing basis. We base our estimates on historical experience and on various other factors that we believe are reasonable under the circumstances, the results of which form the basis for making judgments about the carrying value of assets and liabilities that are not readily apparent from other sources. Actual results may differ from these estimates under different assumptions or conditions.

Research and Development Expense and Accruals

As part of the process of preparing our consolidated financial statements, we are required to estimate certain research and development expenses. This process involves reviewing quotations and contracts, reviewing the terms of our license agreements, communicating with our vendors and applicable personnel to identify services that have been performed on our behalf and estimating the level of service performed and the associated cost incurred for the service when we have not yet been invoiced or otherwise notified of the actual cost. The majority of our service providers invoice us monthly in arrears for services performed or when contractual milestones are met. Payments made prior to the receipt of goods or services to be used in research and development are capitalized until the goods or services are received. Such payments are evaluated for current or long-term classification based on when they will be realized or consumed. Examples of estimated amortized or accrued research and development expenses include fees to:

- contract research organizations (CROs) and other service providers in connection with clinical studies;
- contract manufacturing organizations (CMOs) in connection with the production of clinical trial materials; and
- vendors in connection with preclinical development activities.

We base our expenses related to clinical studies on our estimates of the services received and efforts expended pursuant to contracts with multiple research institutions and CROs that conduct and manage clinical studies on our behalf. The financial terms of these agreements are subject to negotiation, vary from contract to contract and may result in uneven payment flows and expense recognition. Payments under some of these contracts depend on factors such as the successful enrollment of patients and the completion of clinical trial milestones. In either amortizing or accruing service fees, we estimate the time period over which services will be performed and the level of effort to be expended in each period. If the actual timing of the performance of services or the level of effort varies from our estimate, we adjust the related prepayment or accrual accordingly. Our understanding of the status and timing of services performed relative to the actual status and timing of services performed may vary and may result in our reporting changes in estimates in any particular period. Adjustments to prior period estimates have not been material for the years ended December 31, 2022 and 2021.

We have and may continue to enter into license agreements to access and utilize certain technology. In each case, we evaluate if the license agreement results in the acquisition of an asset or a business. To date, none of our license agreements have been considered to be acquisitions of businesses. For asset acquisitions, the upfront payments to acquire such licenses, as well as any future milestone payments, are immediately recognized as research and development expense when paid, provided there is no alternative future use of the rights in other research and development projects. These license agreements may also include contingent consideration in the form of cash payments to be made for future milestone events. We assess whether such contingent consideration meets the definition of a derivative and to date we have determined that such contingent consideration are not derivatives.

Goodwill and Indefinite-Lived Intangible Asset

Prior to their full impairment in 2021, goodwill and our indefinite-lived intangible asset were reviewed for impairment at least annually in the fourth quarter and more frequently if events or other changes in circumstances indicated the carrying amount of the assets may not have been recoverable.

Goodwill

We have one operating segment and reporting unit. Accordingly, our review of goodwill impairment indicators was performed at the entity-wide level. In performing each annual impairment assessment and any interim impairment assessment, we determined if we should qualitatively assess whether it was more likely than not the fair value of goodwill was less than its carrying amount (the qualitative impairment test). Some of the factors considered in the assessment included general macroeconomic conditions, conditions specific to the industry and market, cost factors, the overall financial performance and whether there had been sustained declines in our share price. If we concluded it was more likely than not the fair value of the reporting unit was less than its carrying amount, or elected not to use the qualitative impairment test, a quantitative impairment test was performed.

We used our market capitalization as an indicator of fair value. We believe that since our reporting unit is publicly traded, the ability of a controlling stockholder to benefit from synergies and other intangible assets which arise from control might cause the fair value of our reporting unit as a whole to exceed our market capitalization. However, we believe the fair value measurement need not be based solely on the quoted market price of an individual share of our common stock, but also can consider the impact of a control premium in measuring the fair value of its reporting unit. The control premium utilized was based on control premiums observed in recent acquisitions of entities similar to us which were made on a non-minority basis. Should our market capitalization have been less than our total stockholders' equity as of our annual test date or as of any interim impairment testing date, we also considered market comparables, trends in our stock price over a reasonable period and, if appropriate, used an income approach (discounted cash flow) to determine whether the fair value of our reporting unit was greater than our carrying amount. When we used an income approach, we established a fair value by estimating the present value of our projected future cash flows, adjusted for probabilities of technical success, expected to be generated from our business. The discount rate applied to the projected future cash flows to arrive at the present value was intended to reflect all risks of ownership and the associated risks of realizing the stream of projected future cash flows. Our discounted cash flow methodology considered projections of financial performance for a period of several years combined with an estimated residual value.

We elected to perform a quantitative impairment assessment of goodwill for our single reporting unit in 2021 due to a sustained decline in our market capitalization, an increase in negative economic outlook for biotech markets and a fourth quarter unfavorable clinical trial result for a competitor's curative combination therapy for HBV infection. We estimated and reconciled the fair value of our reporting unit using both a market approach, utilizing our market capitalization adjusted for an estimated control premium, and the income approach, discounting future cash flows based on management's expectations of timelines to complete clinical trials, regulatory and commercial probabilities of technical success as well as future earnings forecast. Before completing our goodwill impairment test, we first tested our indefinite-lived intangible asset then our remaining long-lived assets for impairment. We concluded our indefinite-lived intangible asset was fully impaired and included that impairment within the net carrying value of our reporting unit for purposes of our goodwill impairment test. No impairment was identified for our long-lived assets. We concluded the fair value of our single reporting unit was less than its carrying value and therefore recognized an impairment charge of $12.6 million during 2021 to write off the entire balance of our goodwill. This was primarily due to an increase in discount rates from the standpoint of a market participant and their views on how such aforementioned events increase the risks associated with the Company. The fair value measurements were primarily based on Level 3 inputs. The calculation of the impairment charge included substantial fact-based determinations and estimates including discount rates, future revenues, profitability, cash flows, probabilities of technical success, and fair values of assets and liabilities, and any changes to these assumptions could result in changes to the fair value of our single reporting unit. The goodwill impairment charge is reflected in impairment of goodwill and indefinite-lived intangible asset in the consolidated statements of operations and comprehensive loss for the year ended December 31, 2021.

Indefinite-Lived Intangible Asset

Our indefinite-lived intangible asset consisted of in-process research and development (IPR&D) associated with small molecule CIs that directly target and allosterically inhibit core protein functions associated with HBV that were

acquired with the acquisition of Assembly Pharmaceuticals, Inc. in 2014. IPR&D represented the fair value assigned to incomplete research projects we acquired through a business combination which, at the time of acquisition, had not reached technological feasibility, regardless of whether they had alternative use. The primary basis for determining the technological feasibility or completion of these projects was obtaining regulatory approval to market the underlying products in an applicable geographic region. We classified IPR&D acquired in a business combination as an indefinite-lived intangible asset until the associated research and development efforts were either completed or abandoned. Upon completion of the associated research and development efforts, we would perform a final test for impairment and would determine the useful life of the technology and begin amortizing the assets to reflect their use over their remaining lives. Upon permanent abandonment, we would write off the remaining carrying amount of the associated IPR&D intangible asset.

In performing each annual impairment assessment and any interim impairment assessment, we determined if we should qualitatively assess whether it was more likely than not the fair value of our IPR&D asset was less than its carrying amount (the qualitative impairment test). If we concluded that was the case, or elected not to use the qualitative impairment test, we would proceed with quantitatively determining the fair value of the IPR&D asset and comparing its fair value to its carrying value to determine the amount of impairment, if any (the quantitative impairment test).

In performing the qualitative impairment test, we considered the results of the most recent quantitative impairment test and identified the most relevant drivers of the fair value for the IPR&D asset. The most relevant drivers of fair value we identified were consistent with the assumptions used in the quantitative estimate of the IPR&D asset discussed below. Using these drivers, we identified events and circumstances that may have had an effect on the fair value of the IPR&D asset since the last time the IPR&D's fair value was quantitatively determined. We then weighed these factors to determine and conclude if it was more likely than not the IPR&D asset was impaired. If it was more likely than not the IPR&D asset was impaired, we proceeded with quantitatively determining the fair value of the IPR&D asset.

We used the income approach to determine the fair value of our IPR&D asset. This approach calculates fair value by estimating the after-tax, probability of technical success adjusted, cash flows attributable to an in-process project over its useful life and then discounting these after-tax cash flows back to a present value. This estimate included significant assumptions regarding the estimates market participants would make in evaluating the IPR&D asset, including the probability of successfully completing clinical trials and obtaining regulatory approval to market the IPR&D asset, the timing of and the expected costs to complete IPR&D projects, future net cash flows from potential drug sales, which were based on estimates of the sales price of the drug, the number of patients who will be diagnosed and treated and our competitive position in the marketplace, and appropriate discount and income tax rates. The fair value of our IPR&D asset could vary based on the significant assumptions described. Any impairment to be recorded was calculated as the difference between the fair value of the IPR&D asset as of the date of the assessment with the carrying value of the IPR&D asset on our consolidated balance sheet.

In 2021, we also completed a quantitative impairment test for our IPR&D asset associated with the Assembly Pharmaceuticals, Inc. acquisition prior to the goodwill impairment test. We utilized the discounted cash flow model of the income approach and determined the carrying value of our IPR&D asset was fully impaired resulting in an impairment charge of $29.0 million during 2021. This was primarily driven by a higher discount rate applied to future cash flows based on a market participant's view of increased risk associated with a negative economic outlook for biotech markets and a fourth quarter unfavorable clinical trial result for a competitor's curative combination therapy for HBV infection. The fair value measurements were primarily based on Level 3 inputs. Some of the more significant assumptions inherent in the development of the model included the estimated annual cash flows, particularly net revenues, the appropriate discount rate to select in order to measure the risk inherent in the future cash flows, cost to complete the IPR&D project as well as other factors. The impairment charge recorded is reflected in impairment of goodwill and indefinite-lived intangible asset in the consolidated statements of operations and comprehensive loss for the year ended December 31, 2021.

Results of Operations

General

At December 31, 2022, we had an accumulated deficit of $724.5 million primarily as a result of research and development expenses and general and administrative expenses. While we may in the future generate revenue from a variety of sources, including license fees, milestone payments, research and development payments in connection with strategic partnerships and/or product sales, our product candidates are in the clinical stage of development or in varying stages of nonclinical development and may never be successfully developed or commercialized. Accordingly, we expect to continue to incur substantial losses from operations for the foreseeable future and there can be no assurance we will ever generate significant revenues.

Comparison of the Years Ended December 31, 2022 and 2021

Collaboration Revenue

The following table summarizes the period-over-period changes in our collaboration revenue (in thousands, except for percentages):

	Year Ended December 31,		$ Change	% Change
	2022	2021	2022 vs. 2021	2022 vs. 2021
Collaboration revenue	$ —	$ 6,254	$ (6,254)	(100)%

There was no collaboration revenue for the year ended December 31, 2022. Collaboration revenue for the year ended December 31, 2021 consists of the recognition of deferred revenue allocated to 2158 under our collaboration agreement with BeiGene, Ltd. (the BeiGene Agreement) upon discontinuing development of 2158.

Research and Development Expense

Research and development expenses consist primarily of employee-related expenses, fees paid to CROs and CMOs, lab supplies and other third party expenses that support our research and discovery, nonclinical and clinical activities. We use our employee and infrastructure resources, as well as certain third-party costs, across multiple research and development programs, and we do not specifically allocate these costs to our programs.

The following table summarizes the period-over-period changes in our research and development expenses (in thousands, except for percentages):

	Year Ended December 31,		$ Change	% Change
	2022	2021	2022 vs. 2021	2022 vs. 2021
External expenses:				
Research and discovery	$ 10,338	$ 6,274	4,064	65%
3733	8,165	2,335	5,830	250%
VBR	6,962	16,012	(9,050)	(57)%
4334	5,195	2,796	2,399	86%
2158	2,440	9,916	(7,476)	(75)%
Microbiome	—	(2,579) [1]	2,579	(100)%
Total external expenses	33,100	34,754	(1,654)	(5)%
Employee and contractor-related expenses	31,052	26,423	4,629	18%
Facility and other expenses	5,828	7,347	(1,519)	(21)%
Total research and development expenses	$ 69,980	$ 68,524	$ 1,456	2%

[1] Microbiome external expenses in 2021 include a $3.0 million gain on the sale of Microbiome assets.

Research and development expenses were $70.0 million for the year ended December 31, 2022 compared to $68.5 million for the year ended December 31, 2021. The $1.5 million increase in research and development expenses was primarily driven by increases in employee and contractor-related expenses of $4.6 million due to the reversal in 2021 of $4.8 million of previously recognized stock-based compensation expense related to forfeited awards of terminated employees, of which $2.7 million resulted from the wind-down of our Microbiome program, as well as increases in salaries and benefits primarily due to severance costs incurred related to the reorganization announced in July 2022. We also experienced increases in external expenses generated from the advancement of 3733, our research discovery programs, which expand our portfolio beyond CIs, and advancement of 4334 to a Phase 1a trial which was initiated in 2022. This was partially offset by decreases in external expenses due to our discontinuation of the VBR, 2158 and Microbiome programs, net of a $3.0 million gain on the sale of Microbiome assets recognized during the year ended December 31, 2021, and a decrease in facility and other expenses of $1.5 million primarily attributable to asset impairment and other charges incurred in 2021 in connection with the wind-down of the Microbiome program.

General and Administrative Expense

General and administrative expenses consist primarily of salaries and other related costs for personnel in executive, finance, accounting, business development, information technology, legal and human resources functions. Other significant costs include facility costs not otherwise included in research and development expenses, insurance costs, legal fees relating to patents and corporate matters and fees for accounting and consulting services.

The following table summarizes the period-over-period change in our general and administrative expenses (in thousands, except for percentages):

	Year Ended December 31,		$ Change	% Change
	2022	2021	2022 vs. 2021	2022 vs. 2021
				%
General and administrative expenses	$ 24,134	$ 28,780	$ (4,646)	(16)

General and administrative expenses were $24.1 million for the year ended December 31, 2022, compared to $28.8 million for the year ended December 31, 2021. The decrease of $4.6 million in general and administrative expenses was primarily due to a $1.7 million decrease in professional fees attributable to reductions in legal and outside consulting-related expenses and the amortization of incremental contract costs under the BeiGene Agreement upon discontinuing development of 2158 in 2021. We also experienced decreases of $1.1 million in stock-based compensation expense in 2022 primarily due to a decrease in the grant date fair value of recent option grants, $0.6 million in salaries and benefits as a result of no bonus being due to our former Chief Executive Officer following his retirement, $0.5 million in facility-related expenses primarily due to termination of lease agreements related to the wind-down of the Microbiome program in 2021 and $0.5 million in recruitment expenses due to hiring of fewer employees during the year ended December 31, 2022 compared to the same period in 2021. The severance costs incurred related to the reorganization announced in July 2022 were offset by a reduction in bonuses for those impacted by the reorganization.

Impairment of Goodwill and Indefinite-Lived Intangible Asset

The following table summarizes the period-over-period change in our impairment of goodwill and indefinite-lived intangible asset (in thousands, except for percentages):

	Year Ended December 31,		$ Change	% Change
	2022	2021	2022 vs. 2021	2022 vs. 2021
Impairment of goodwill and indefinite-lived intangible asset.....	$ —	$ 41,638	$ (41,638)	-100%

In the fourth quarter of 2021, we concluded our goodwill and IPR&D asset were impaired due to a sustained decline in our stock price as well as industry and market factors which caused an increase in the estimated discount rate applied to future cash flows. This resulted in the entire write-off of our goodwill and IPR&D asset of $12.6 million and $29.0 million, respectively.

Interest and Other Income, Net

Interest income consists of interest earned on our cash and cash equivalents and available-for-sale securities.

The following table summarizes the period-over-period changes in our interest and other income, net (in thousands, except for percentages):

	Year Ended December 31,		$ Change	% Change
	2022	2021	2022 vs. 2021	2022 vs. 2021
Interest and other income, net	$ 1,022	$ 302	$ 720	238%

Interest and other income, net was $1.0 million for the year ended December 31, 2022, compared to $0.3 million for the year ended December 31, 2021. The increase of $0.7 million was primarily due to more interest income earned on marketable securities caused by multiple interest rate increases in 2022.

Income Tax Benefit

The following table summarizes the period-over-period changes in our income tax benefit (in thousands, except for percentages):

	Year Ended December 31,		$ Change	% Change
	2022	2021	2022 vs. 2021	2022 vs. 2021
Income tax benefit	$ —	$ 2,531	$ (2,531)	-100%

There was no income tax benefit recognized during the year ended December 31, 2022. During the year ended December 31, 2021, we recognized an income tax benefit of $2.5 million due to the reversal of deferred tax liabilities associated with our IPR&D which was fully impaired in 2021.

Liquidity and Capital Resources

Sources of Liquidity

As a result of our significant research and development expenditures and the lack of any FDA-approved products to generate product sales revenue, we have not been profitable and have generated operating losses since we were incorporated in October 2005. We have funded our operations through December 31, 2022 principally with debt prior to our initial public offering, and thereafter with equity financing, raising an aggregate of $605.0 million in net proceeds from public offerings and private placements from inception to December 31, 2022.

In 2021, we sold an aggregate of 11,234,207 shares of common stock under our "at-the-market" offering program (2020 ATM), resulting in net proceeds of $52.8 million.

In 2022, we sold an aggregate of 300,827 shares of common stock through the 2020 ATM, resulting in net proceeds of $0.3 million.

Future Funding Requirements

We expect our future operating expenses to decrease as we continue to realize cost savings from our strategic reorganization plan we implemented in July 2022. However, we will need to obtain substantial additional funding in connection with our continuing operations. If we are unable to raise capital when needed or on attractive terms, we could be forced to delay, reduce or eliminate our research and development programs or future commercialization efforts.

We monitor our cash needs and the status of the capital markets on a continuous basis. From time to time, we opportunistically raise capital and have done so numerous times since our initial public offering by issuing equity securities. We expect to continue to raise capital when and as needed and at the time and in the manner most advantageous to us.

We expect our existing cash, cash equivalents and marketable securities will enable us to fund our operating expenses and capital expenditure requirements for at least the next twelve months. Our contractual obligations include operating lease obligations totaling $3.5 million as of December 31, 2022, of which $3.4 million are short-term. We also enter into contracts in the normal course of business with CROs for clinical trials and CMOs for clinical supply manufacturing and with vendors for preclinical research studies and other services and products for operating purposes, which generally provide for termination within 30 days of notice. Since our inception, we have not engaged in any off-balance sheet arrangements as defined in Item 303(a)(4) of Regulation S-K.

Our future capital requirements will depend on many factors, including:

- our ability to raise capital despite macroeconomic and geopolitical events impacting financial markets, such as rising inflation, market volatility and risk of recession;
- the scope, progress, results and costs of our ongoing drug discovery, nonclinical development, laboratory testing and clinical studies of our product candidates and any additional clinical studies we may conduct in the future;
- our ability to manufacture, and to contract with third parties to manufacture, adequate supplies of our product candidates for our clinical studies and any eventual commercialization;
- the costs, timing and outcome of regulatory review of our product candidates;
- the costs of preparing, filing and prosecuting patent applications in the United States and abroad, maintaining and enforcing our intellectual property rights and defending intellectual property-related claims; and
- our ability to establish and maintain collaborations on favorable terms, if at all.

Identifying potential product candidates and conducting nonclinical testing and clinical studies is a time-consuming, expensive and uncertain process that takes years to complete, and we may never generate the necessary data or results required to obtain marketing approval and achieve product sales. In addition, our product candidates, if approved, may not achieve commercial success. Our commercial revenues, if any, will be derived from sales of medicines that we do not expect to be commercially available for years, if at all. Accordingly, we will need to continue to rely on additional financings to achieve our business objectives. Adequate additional financings may not be available to us on acceptable terms, or at all.

Until such time, if ever, as we can generate substantial product revenues, we expect to finance our cash needs through a combination of equity offerings, debt financings, collaborations, strategic alliances and licensing arrangements. We do not have any committed external source of funds. To the extent that we raise additional capital through the sale of equity or convertible debt securities, the ownership interest of our stockholders will be diluted, and the terms of these securities may include liquidation or other preferences that adversely affect the rights of our common stockholders. Debt financing, if available, may involve agreements that include covenants limiting or restricting our ability to take specific actions, such as incurring additional debt, making capital expenditures or declaring dividends.

If we raise funds through additional collaborations, strategic alliances or licensing arrangements with third parties, we may have to relinquish valuable rights to our technologies, future revenue streams, research programs or product candidates or to grant licenses on terms that may not be favorable to us. If we are unable to raise additional funds through equity or debt financings when needed, we may be required to delay, limit, reduce or terminate our product development or future commercialization efforts or grant rights to develop and market product candidates that we would otherwise prefer to develop and market ourselves.

Cash Flows

A summary of our cash flows for the periods presented was as follows (in thousands):

	Year Ended December 31,	
	2022	**2021**
Operating activities	$ (84,463)	$ (93,396)
Investing activities	90,640	26,515
Financing activities	614	53,064
Net increase (decrease) in cash and cash equivalents	$ 6,791	$ (13,817)

Net Cash Used in Operating Activities

Net cash used in operating activities was $84.5 million for the year ended December 31, 2022. This was primarily due to our net loss of $93.1 million, adjusted for $6.6 million recognized for stock-based compensation expense.

Net cash used in operating activities was $93.4 million for the year ended December 31, 2021. This was primarily due to our net loss of $129.9 million, which included the recognition of $41.6 million in non-cash charges for the impairment of our goodwill and indefinite-lived intangible asset and $6.3 million in collaboration revenue from deferred revenue allocated to 2158 under the BeiGene Agreement upon discontinuing development of 2158.

Net Cash Provided by Investing Activities

Net cash provided by investing activities for the year ended December 31, 2022 was $90.6 million due to proceeds of $89.2 million from sales and maturities of marketable securities, net of purchases, and proceeds of $1.5 million received in 2022 from the sale of Microbiome assets in 2021.

Net cash provided by investing activities for the year ended December 31, 2021 was $26.5 million. This was due to proceeds of $27.3 million from sales and maturities of marketable securities, net of purchases, and proceeds of $1.5 million from the sale of Microbiome assets. This was partially offset by our purchase of leased equipment for $3.1 million that we then sold for $0.9 million in connection with the wind-down of the Microbiome program.

Net Cash Provided by Financing Activities

Net cash provided by financing activities for the year ended December 31, 2022 was $0.6 million resulting from the net proceeds of $0.3 million from the sale of 300,827 shares of our common stock under the 2020 ATM and $0.3 million from the issuance of 225,832 shares of common stock under the Assembly Biosciences Amended and Restated 2018 Employee Stock Purchase Plan (2018 ESPP).

Net cash provided by financing activities for the year ended December 31, 2021 was $53.1 million resulting from the net proceeds of $52.8 million from the sale of 11,234,207 shares of our common stock under the 2020 ATM and $0.3 million from the issuance of 88,820 shares of common stock under the 2018 ESPP.

Item 7A. Quantitative and Qualitative Disclosures about Market Risk

Not applicable.

Item 8. Financial Statements and Supplementary Data

(a) Financial Statements

The financial statements required to be filed pursuant to this Item 8 are appended to this report. An index of those financial statements is found on page F-1.

(b) Supplementary Data

Not applicable.

Item 9. Changes in and Disagreements with Accountants on Accounting and Financial Disclosure

None.

Item 9A. Controls and Procedures

Evaluation of Disclosure Controls and Procedures

We maintain a system of disclosure controls and procedures, as defined in Rule 13a-15(e) promulgated under the Securities and Exchange Act of 1934, as amended (the Exchange Act), that is designed to provide reasonable assurance that information, which is required to be disclosed in our reports filed pursuant to the Exchange Act, is accumulated and communicated to management in a timely manner. At the end of fiscal year ending December 31, 2022, we carried out an evaluation, under the supervision, and with the participation of, our management, including our Chief Executive Officer, who serves as our principal executive officer and principal financial officer, of the effectiveness of the design and operation of our disclosure controls and procedures pursuant to Exchange Act Rule 13a-15(b). Based upon that evaluation, our Chief Executive Officer concluded that our disclosure controls and procedures for the fiscal year ending as of December 31, 2022 were effective at reasonable assurance levels.

Management's Annual Report on Internal Control over Financial Reporting

Our management is responsible for establishing and maintaining adequate internal control over financial reporting, as such term is defined in Exchange Act Rule 13a-15(f). Our internal control over financial reporting is designed to provide reasonable assurance to our management and Board of Directors regarding the preparation and fair presentation of published financial statements. A control system, no matter how well designed and operated, can only provide reasonable, not absolute, assurance that the objectives of the control system are met. Because of these inherent limitations, management does not expect that our internal controls over financial reporting will prevent all error and all fraud. Under the supervision and with the participation of our management, including our Chief Executive Officer, who serves as our principal executive officer and principal financial officer, we conducted an evaluation of the effectiveness of our internal control over financial reporting based on the framework in Internal Control-Integrated Framework issued in 2013 by the Committee of Sponsoring Organizations of the Treadway Commission. Based on our evaluation under the framework in Internal Control-Integrated Framework, our management concluded that our internal control over financial reporting was effective as of December 31, 2022.

Changes in Internal Control over Financial Reporting

There were no changes in our internal control over financial reporting in the fourth quarter of 2022 that materially affected, or are reasonably likely to materially affect, our internal control over financial reporting.

Item 9B. Other Information

Not applicable.

Item 9C. Disclosure Regarding Foreign Jurisdictions that Prevent Inspections

Not applicable.

PART III

Item 10. Directors, Executive Officers and Corporate Governance

Except as set forth below, the information required by this item will be contained in our definitive proxy statement to be filed with the SEC in connection with the Annual Meeting of Stockholders (Proxy Statement) within 120 days after the conclusion of our fiscal year ended December 31, 2022 and is incorporated in this Annual Report on Form 10-K by reference.

Code of Ethics

Our Board has adopted a Code of Ethics for our principal executive officer and all senior financial officers and a Code of Conduct applicable to all of our employees and our directors. Both Codes are available under the "Investors—Corporate Governance" section of our website at www.assemblybio.com. If we make any substantive amendments to, or grant any waivers from, the Code of Ethics for our principal executive officer, principal financial officer, principal accounting officer, controller or persons performing similar functions, or any officer or director, we will disclose the nature of such amendment or waiver on our website or in a Current Report on Form 8-K.

Item 11. Executive Compensation

The information required by this item will be contained in the Proxy Statement and is incorporated into this Annual Report on Form 10-K by reference.

Item 12. Security Ownership of Certain Beneficial Owners and Management and Related Stockholder Matters

Except for the table regarding equity compensation plans, the information required by this item will be contained in the Proxy Statement and is incorporated into this Annual Report on Form 10-K by reference.

Securities Authorized for Issuance Under Equity Compensation Plans

The following table sets forth the indicated information as of December 31, 2022 with respect to our equity compensation plans.

Plan Category	Number of securities to be issued upon exercise of outstanding options, warrants and rights (a)		Weighted average exercise price of outstanding options, warrants and rights[1] (b)	Number of securities remaining available for future issuance under equity compensation plans (excluding securities reflected in column (a)) (c)	
Equity compensation plans approved by securityholders	9,118,366	(2)	$ 4.49	2,828,469	(3)
Equity compensation plans not approved by securityholders	1,672,263	(4)	$ 14.00	364,465	(5)
Total.....	10,790,629			3,192,934	

(1) The weighted average exercise price is calculated solely based on the exercise prices of the outstanding stock options and does not reflect the shares that will be issued upon the vesting of outstanding awards of restricted stock units (RSUs), which have no exercise price.

(2) This number includes the following: 248,369 shares subject to stock options granted under the 2010 Equity Incentive Plan (2010 Plan); 1,543,737 shares subject to outstanding awards granted under the Assembly

Biosciences, Inc. Amended and Restated 2014 Stock Incentive Plan (2014 Plan), of which 1,541,237 were subject to outstanding stock options and 2,500 were subject to outstanding RSUs; 6,864,632 shares subject to outstanding awards granted under the Assembly Biosciences, Inc. 2018 Stock Incentive Plan, as amended (2018 Plan), of which 5,214,008 were subject to outstanding stock options, 1,646,014 were subject to outstanding RSUs and 4,610 are underlying stock appreciation rights (which are not included in column (a) but are reflected in column (c)); and 466,238 options assumed by us in connection with our merger with Assembly Pharmaceuticals. This number excludes purchase rights currently accruing under the Assembly Biosciences, Inc. Amended and Restated 2018 Employee Stock Purchase Plan (2018 ESPP).

(3) This number includes: no shares under the 2010 Plan, which has been frozen; 966,303 shares available for issuance under the 2014 Plan; 1,044,483 shares available for issuance under the 2018 Plan; and 817,683 shares reserved for issuance under the 2018 ESPP. As of March 9, 2023, assuming each participant purchases the maximum number of shares in the current offering period, no more than 107,500 shares are subject to purchase in the current offering, which ends on May 12, 2023.

(4) This number includes 575,640 shares subject to outstanding awards granted under the 2017 Inducement Award Plan (2017 Inducement Plan), of which 571,890 were subject to outstanding stock options and 3,750 were subject to outstanding RSUs; 500,000 shares subject to stock options granted under the 2019 Inducement Award Plan (2019 Inducement Plan); and 596,623 shares subject to outstanding awards granted under the 2020 Inducement Award Plan (2020 Inducement Plan), of which 549,123 were subject to outstanding stock options and 47,500 were subject to outstanding RSUs.

(5) This number includes: 208,588 shares available for issuance under the 2017 Inducement Plan, no shares under the 2019 Inducement Plan and 155,877 shares available for issuance under the 2020 Inducement Plan.

Our stockholder-approved equity compensation plans consist of the 2018 Plan, 2014 Plan, the 2010 Plan, stock options assumed in our merger with Assembly Pharmaceuticals and the 2018 ESPP. Effective on June 2, 2016, the 2010 Plan was frozen, and no further grants will be made under the 2010 Plan. Shares that are forfeited under the 2010 Plan on or after June 2, 2016 will become available for issuance under the 2014 Plan. An “Award” under the 2018 Plan, 2014 Plan or 2010 Plan is any right to receive our common stock consisting of non-statutory stock options, incentive stock options, stock appreciation rights, RSUs, or any other stock award.

In May 2018, our stockholders approved the 2018 ESPP and was amended and restated in May 2021. The 2018 ESPP provides for the purchase by employees of up to an aggregate of 1,300,000 shares of the Company’s common stock. Eligible employees can purchase shares of our common stock at the end of a predetermined offering period at 85% of the lower of the fair market value at the beginning or end of the offering period.

Our outstanding equity compensation arrangements that have not been approved by our stockholders consist of the 2017 Inducement Plan, the 2019 Inducement Plan and the 2020 Inducement Plan. In April 2017, our board of directors adopted the 2017 Inducement Plan and reserved 800,000 shares of our common stock for issuance under 2017 the Inducement Plan. In August 2019, our board of directors adopted the 2019 Inducement Plan and reserved 500,000 shares of our common stock for issuance under the 2019 Inducement Plan. In March 2020, our board of directors adopted the 2020 Inducement Plan and reserved 800,000 shares of our common stock for issuance under the 2020 Inducement Plan. The only persons eligible to receive grants of awards under the 2017 Inducement Plan, the 2019 Inducement Plan or the 2020 Inducement Plan are individuals who satisfy the standards for inducement grants under Nasdaq Marketplace Rule 5635(c)(4) and the related guidance under Nasdaq IM 5635-1-that is, generally, a person not previously an employee or director of ours, or following a bona fide period of non-employment, as an inducement material to the individual's entering into employment with us. An “Award” is any right to receive our common stock pursuant to the Inducement Plan, consisting of nonstatutory stock options, stock appreciation rights, restricted stock awards, RSUs, or any other stock award.

Item 13. Certain Relationships and Related Party Transactions, and Director Independence

The information required by this item will be contained in the Proxy Statement and is incorporated into this Annual Report on Form 10-K by reference.

Item 14. Principal Accountant Fees and Services

The information required by this item will be contained in the Proxy Statement and is incorporated into this Annual Report on Form 10-K by reference.

Item 15. Exhibits, Financial Statement Schedules

(a) *Exhibits.* The following exhibits are filed as part of this Annual Report on Form 10-K:

Exhibit Number	Description of Document	Registrant's Form	Dated	Exhibit No.	Filed Herewith
3.1	Sixth Amended and Restated Certificate of Incorporation dated May 25, 2022.	8-K	05/27/2022	3.1	
3.2	Amended and Restated Bylaws as amended through December 7, 2022.	8-K	12/12/2022	3.1	
4.1	Specimen of Common Stock Certificate.	S-3	12/30/2015	4.1	
4.2	Description of Securities.				X
10.1	Sub-Sublease, dated as of July 18, 2018, between Prothena Biosciences, Inc., as Sub-Sublandlord, and Assembly Biosciences, Inc., as Sub-Subtenant.	10-Q	11/08/2018	10.1	
10.2*	Exclusive License Agreement dated September 3, 2013 by and between The Indiana University Research and Technology Corporation and Assembly Pharmaceuticals, Inc.	10-Q	11/17/2014	10.29	
10.3†	Amendment No. 1 to Exclusive License Agreement, by and between Assembly Biosciences, Inc. and the Indiana University Research and Technology Corporation.	10-Q	11/05/2020	10.1	
10.4†	Amendment No. 2 to Exclusive License Agreement, by and between Assembly Biosciences, Inc. and the Indiana University Research and Technology Corporation.	10-Q	11/05/2020	10.2	
10.5†‡	Collaboration Agreement, dated as of July 17, 2020, by and between Assembly Biosciences, Inc. and BeiGene, Ltd.	10-Q	11/05/2020	10.3	
10.7#	Amended and Restated Employment Agreement, dated December 12, 2023, between Assembly Biosciences, Inc. and Jason A. Okazaki.				X
10.8#	Employment Agreement, dated May 1, 2020, between Assembly Biosciences, Inc. and William E. Delaney IV, Ph.D., effective as of May 27, 2020.	10-K	02/25/2021	10.12	
10.9#	2010 Equity Incentive Plan.	S-1/A	10/4/2010	10.14	
10.10#	Assembly Biosciences, Inc. Amended and Restated 2014 Stock Incentive Plan.	8-K	06/06/2016	10.1	
10.11#	Omnibus Amendment to Assembly Biosciences, Inc. Stock Incentive Plans.	10-Q	05/08/2020	10.2	
10.12#	Form of Notice of Stock Option Grant and Stock Option Agreement under Amended and Restated 2014 Stock Incentive Plan.				X
10.13#	Form of Restricted Stock Unit Award Notice and Restricted Stock Unit Award Agreement under the Amended and Restated 2014 Stock Incentive Plan.	10-Q	11/01/2017	10.1	
10.14#	Assembly Biosciences, Inc. 2017 Inducement Award Plan.	10-Q	08/09/2017	10.1	
10.15#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2017 Inducement Award Plan.	10-Q	08/09/2017	10.2	
10.16#	Form of Restricted Stock Unit Award Notice and Restricted Stock Unit Award Agreement under the 2017 Inducement Award Plan.	10-Q	08/09/2017	10.3	
10.17#	Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	06/01/2018	10.1	

Exhibit Number	Description of Document	Registrant's Form	Dated	Exhibit No.	Filed Herewith
10.18#	Amendment No. 1 to Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	05/21/2019	10.2	
10.19#	Amendment No. 3 to Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	06/16/2020	10.1	
10.20#	Amendment No. 4 to Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	05/25/2021	10.1	
10.21#	Amendment No. 5 to Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	05/27/2022	10.1	
10.22#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2018 Stock Incentive Plan.				X
10.23#	Form of Restricted Stock Unit Award Notice and Restricted Stock Unit Award Agreement under the 2018 Stock Incentive Plan.	8-K	06/01/2018	10.3	
10.24#	Form of Stock Appreciation Right Award Agreement for Non-U.S. Grantees under the Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	10/12/2018	10.4	
10.25#	Form of Performance-Based Stock Appreciation Right Award Agreement for Non-U.S. Grantees under the Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	10-K	03/11/2022	10.24	
10.26#	Amended and Restated Assembly Biosciences, Inc. 2018 Employee Stock Purchase Plan.	8-K	05/25/2021	10.4	
10.27#	Assembly Biosciences, Inc. 2019 Inducement Award Plan.	10-Q	11/07/2019	10.4	
10.28#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2019 Inducement Award Plan.	10-Q	11/07/2019	10.5	
10.29#	Assembly Biosciences, Inc. 2020 Inducement Award Plan.	10-Q	05/08/2020	10.3	
10.30#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2020 Inducement Award Plan.	10-Q	05/08/2020	10.4	
10.31#	Form of Restricted Stock Unit Award Notice and Restricted Stock Unit Award Agreement under the 2020 Inducement Award Plan.	10-Q	05/08/2020	10.5	
10.32#	Assembly Biosciences, Inc. 2022 Corporate Bonus Plan.	8-K	02/17/2021	10.1	
10.33	Open Market Sale Agreement by and between Assembly Biosciences, Inc. and Jefferies LLC.	S-3	08/28/2020	1.2	
10.34#	Assembly Biosciences, Inc. 2022 Corporate Bonus Plan.	8-K	02/04/2022	10.1	
21.1	List of Subsidiaries of Assembly Biosciences, Inc.				X
23.1	Consent of Independent Registered Public Accounting Firm.				X
24.1	Power of Attorney (included on signature page).				X
31.1	Certification of the Chief Executive Officer Pursuant to Section 302 of the Sarbanes-Oxley Act of 2002.				X
32.1**	Certification of the Chief Executive Officer Pursuant to 18 U.S.C. Section 1350 as Adopted Pursuant to Section 906 of the Sarbanes-Oxley Act of 2002.				X
101.INS	Inline XBRL Instance Document.				
101.SCH	Inline XBRL Taxonomy Extension Schema Document.				
101.CAL	Inline XBRL Taxonomy Extension Calculation Linkbase Document.				
101.DEF	Inline XBRL Taxonomy Extension Definitions Linkbase Document.				

Exhibit Number	Description of Document	Registrant's Form	Dated	Exhibit No.	Filed Herewith
101.LAB	Inline XBRL Taxonomy Extension Label Linkbase Document.				
101.PRE	Inline XBRL Taxonomy Extension Presentation Linkbase Document.				
104	Cover Page Interactive Data File (embedded within the Inline XBRL document).				

* Certain information in this exhibit has been omitted and filed separately with the Securities and Exchange Commission pursuant to a confidential treatment request.

† The schedules to this exhibit have been omitted pursuant to Item 601(a)(5) of Regulation S-K.

‡ Portions of this exhibit have been omitted pursuant to Item 601(b)(10)(iv) of Regulation S-K.

Represents management contracts or compensatory plans or arrangements.

** The certification attached as Exhibit 32.1 that accompanies this Annual Report on Form 10-K is to be deemed furnished and shall not be deemed "filed" with the SEC and is not to be incorporated by reference into any filing of Assembly Biosciences, Inc. under the Securities Act of 1933, as amended, or the Securities Exchange Act of 1934, as amended, whether made before or after the date of this Annual Report on Form 10-K, irrespective of any general incorporation language contained in such filing.

Item 16. Form 10-K Summary

None.

SIGNATURES

In accordance with Section 13 or 15(d) of the Securities Exchange Act, the Registrant caused this report to be signed on its behalf by the undersigned, thereunto duly authorized.

ASSEMBLY BIOSCIENCES, INC.

Date: March 22, 2023

By: /s/ Jason A. Okazaki
Name: Jason A. Okazaki
Title: Chief Executive Officer and President

POWER OF ATTORNEY

KNOW ALL PERSONS BY THESE PRESENTS, that each person whose signature appears below constitutes and appoints Jason A. Okazaki and John O. Gunderson, jointly and severally, his or her attorneys-in-fact, each with the power of substitution, for him or her in any and all capacities, to sign any amendments to this report, and to file the same, with exhibits thereto and other documents in connection therewith with the Securities and Exchange Commission, hereby ratifying and confirming all that each of said attorneys-in-fact, or his or her substitute or substitutes may do or cause to be done by virtue hereof.

Pursuant to the requirements of the Securities Exchange Act of 1934, this report has been signed by the following persons on behalf of the registrant in the capacities and on the dates indicated.

Signature	Title	Date
/s/ Jason A. Okazaki. Jason A. Okazaki	Chief Executive Officer, President and Director (Principal Executive Officer and Principal Financial Officer)	March 22, 2023
/s/ Jeanette M. Bjorkquist Jeanette M. Bjorkquist	Executive Director, Accounting and Treasury (Principal Accounting Officer)	March 22, 2023
/s/ William R. Ringo, Jr. William R. Ringo, Jr.	Chairman of the Board	March 22, 2023
/s/ Anthony E. Altig Anthony E. Altig	Director	March 22, 2023
/s/ Gina Consylman Gina Consylman	Director	March 22, 2023
/s/ Richard D. DiMarchi, Ph.D. Richard D. DiMarchi, Ph.D.	Director	March 22, 2023
/s/ Sir Michael Houghton, Ph.D. Sir Michael Houghton, Ph.D.	Director	March 22, 2023
/s/ Lisa R. Johnson-Pratt, M.D. Lisa R. Johnson-Pratt, M.D.	Director	March 22, 2023
/s/ Susan Mahony, Ph.D. Susan Mahony, Ph.D.	Director	March 22, 2023
/s/ John G. McHutchison, A.O., M.D. John G. McHutchison, A.O., M.D.	Director	March 22, 2023

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ASSEMBLY BIOSCIENCES, INC.
FINANCIAL STATEMENTS

Report of Independent Registered Public Accounting Firm

To the Stockholders and the Board of Directors of Assembly Biosciences, Inc.

Opinion on the Financial Statements

We have audited the accompanying consolidated balance sheets of Assembly Biosciences, Inc. (the Company) as of December 31, 2022 and 2021, the related consolidated statements of operations and comprehensive loss, changes in stockholders' equity and cash flows for each of the two years in the period ended December 31, 2022, and the related notes (collectively referred to as the "consolidated financial statements"). In our opinion, the consolidated financial statements present fairly, in all material respects, the financial position of the Company at December 31, 2022 and 2021, and the results of its operations and its cash flows for each of the two years in the period ended December 31, 2022, in conformity with U.S. generally accepted accounting principles.

Basis for Opinion

These financial statements are the responsibility of the Company's management. Our responsibility is to express an opinion on the Company's financial statements based on our audits. We are a public accounting firm registered with the Public Company Accounting Oversight Board (United States) (PCAOB) and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement, whether due to error or fraud. The Company is not required to have, nor were we engaged to perform, an audit of its internal control over financial reporting. As part of our audits we are required to obtain an understanding of internal control over financial reporting but not for the purpose of expressing an opinion on the effectiveness of the Company's internal control over financial reporting. Accordingly, we express no such opinion.

Our audits included performing procedures to assess the risks of material misstatement of the financial statements, whether due to error or fraud, and performing procedures that respond to those risks. Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the financial statements. We believe that our audits provide a reasonable basis for our opinion.

Critical Audit Matter

The critical audit matter communicated below is a matter arising from the current period audit of the financial statements that was communicated or required to be communicated to the audit committee and that: (1) relates to accounts or disclosures that are material to the financial statements and (2) involved our especially challenging, subjective or complex judgments. The communication of the critical audit matter does not alter in any way our opinion on the consolidated financial statements, taken as a whole, and we are not, by communicating the critical audit matter below, providing a separate opinion on the critical audit matter or on the accounts or disclosures to which it relates.

Accrued research and development expenses

Description of the Matter

For the year ended December 31, 2022, the Company incurred $70.0 million of research and development expenses and recorded $3.1 million of accrued research and development expenses at December 31, 2022. As described in Note 2 to the consolidated financial statements, the Company's accrued research and development expenses are based on estimates of the services received and efforts expended pursuant to contracts with multiple contract research organizations and manufacturing vendors that conduct and manage these activities on its behalf. When billing terms under such contracts do not coincide with the timing of when the work is performed, management is required to make estimates of outstanding obligations to those third parties as of period end. The accrual is based on a number of factors, including the time period over which services will be performed, enrollment of subjects, number of sites activated, and the level of effort expended in each period. At period end, accrued research and development expenses are recorded based upon estimates of the proportion of work completed over the term of the individual clinical trial and manufacturing activities in accordance with signed agreements with the third parties. The Company obtains information directly from these service providers and performs procedures to challenge these estimates based on their internal understanding of the services provided to date. However, the Company may also be required to estimate these services based on information available to its internal clinical or administrative staff if such information is not able to be obtained timely from its services providers.

Auditing accrued research and development expenses is complex because of the judgments applied by management to determine the commencement and completion date of vendor tasks and the cost and extent of work performed during the reporting period for services not yet billed by contracted third-party vendors. The testing of the Company's accrued research and development expense models also involves a high level of effort to test the high volume of data used to determine the estimated accrual.

How We Addressed the Matter in Our Audit

To test the completeness of accrued research and development expenses, we performed audit procedures that included, among others, direct confirmation of contract terms and conditions with a sample of the Company's third-party vendors. We also confirmed the progress of contracted clinical activities with these third-party vendors and compared such data to the Company's estimates of progress as reflected in their accrual models. We further tested the accuracy of the calculations, the completeness of the data utilized, and the reasonableness of the inputs used in management's accrual models by testing actual invoices paid to date, agreeing inputs back to contractual terms and holding discussions with clinical or administrative staff outside of the finance function. Procedures were performed to evaluate the reliability, completeness and relevance of management's data by testing actual invoices paid and holding discussions with clinical or administrative staff outside of the finance function to corroborate progress and estimated level of expended effort incurred by the Company's third-party vendors. Further, we inspected material invoices received from third parties after the balance sheet date and evaluated whether services performed prior to the consolidated balance sheet date had been properly included in the accrual.

/s/ Ernst & Young LLP
We have served as the Company's auditor since 2015.
San Jose, California
March 22, 2023

ASSEMBLY BIOSCIENCES, INC.
CONSOLIDATED BALANCE SHEETS
(In thousands except for share amounts and par value)

	As of December 31,	
	2022	**2021**
ASSETS		
Current assets		
Cash and cash equivalents	$ 52,418	$ 45,627
Marketable securities - short-term	39,192	101,000
Accounts receivable from collaboration	944	336
Prepaid expenses and other current assets	4,413	7,241
Total current assets	96,967	154,204
Marketable securities - long-term	—	27,972
Property and equipment, net	743	1,139
Operating lease right-of-use (ROU) assets	3,195	6,042
Other assets	889	1,703
Total assets	**$ 101,794**	**$ 191,060**
LIABILITIES AND STOCKHOLDERS' EQUITY		
Current liabilities		
Accounts payable	$ 2,493	$ 2,659
Accrued research and development expenses	3,122	3,400
Other accrued expenses	7,317	6,863
Operating lease liabilities - short-term	3,364	3,151
Total current liabilities	16,296	16,073
Deferred revenue	2,733	2,733
Operating lease liabilities - long-term	101	3,325
Total liabilities	**19,130**	**22,131**
Commitments and contingencies		
Stockholders' equity		
Preferred stock, $0.001 par value; 5,000,000 shares authorized; no shares issued or outstanding	—	—
Common stock, $0.001 par value; 150,000,000 and 100,000,000 shares authorized as of December 31, 2022 and December 31, 2021, respectively; 48,894,973 and 48,120,437 shares issued and outstanding as of December 31, 2022 and December 31, 2021, respectively	49	48
Additional paid-in capital	807,938	800,728
Accumulated other comprehensive loss	(803)	(419)
Accumulated deficit	(724,520)	(631,428)
Total stockholders' equity	82,664	168,929
Total liabilities and stockholders' equity	**$ 101,794**	**$ 191,060**

See Accompanying Notes to the Consolidated Financial Statements

ASSEMBLY BIOSCIENCES, INC.
CONSOLIDATED STATEMENTS OF OPERATIONS AND COMPREHENSIVE LOSS
(In thousands except for share and per share amounts)

	Year Ended December 31,	
	2022	**2021**
Collaboration revenue	$ —	$ 6,254
Operating expenses		
Research and development	69,980	68,524
General and administrative	24,134	28,780
Impairment of goodwill and indefinite-lived intangible asset	—	41,638
Total operating expenses	94,114	138,942
Loss from operations	**(94,114)**	**(132,688)**
Other income		
Interest and other income, net	1,022	302
Total other income	1,022	302
Loss before income taxes	**(93,092)**	**(132,386)**
Income tax benefit	—	2,531
Net loss	**$ (93,092)**	**$ (129,855)**
Other comprehensive loss		
Unrealized loss on marketable securities	(384)	(149)
Comprehensive loss	**$ (93,476)**	**$ (130,004)**
Net loss per share, basic and diluted	$ (1.92)	$ (3.00)
Weighted average common shares outstanding, basic and diluted	48,409,265	43,280,383

See Accompanying Notes to the Consolidated Financial Statements

ASSEMBLY BIOSCIENCES, INC.
CONSOLIDATED STATEMENTS OF CHANGES IN STOCKHOLDERS' EQUITY
(In thousands except for share amounts)

	Common Stock		Additional Paid-in Capital	Accumulated Other Comprehensive Loss	Accumulated Deficit	Total Stockholders' Equity
	Shares	Amount				
Balance as of December 31, 2020	**34,026,680**	**$34**	**$742,387**	**$(270)**	**$(501,573)**	**$240,578**
Issuance of common stock under at-the-market (ATM) equity offering program, net of issuance costs	11,234,207	11	52,795	—	—	52,806
Issuance of common stock under Employee Stock Purchase Plan (ESPP)	88,820	—	258	—	—	258
Issuance of common stock for settlement of restricted stock units (RSUs)	347,096	1	(1)	—	—	—
Issuance of common stock upon cashless exercise of pre-funded warrants	2,423,634	2	(2)	—	—	—
Unrealized loss on marketable debt securities	—	—	—	(149)	—	(149)
Stock-based compensation	—	—	5,291	—	—	5,291
Net loss	—	—	—	—	(129,855)	(129,855)
Balance as of December 31, 2021	**48,120,437**	**$48**	**$800,728**	**$(419)**	**$(631,428)**	**$168,929**
Issuance of common stock under ATM equity offering program, net of issuance costs	300,827	1	324	—	—	325
Issuance of common stock under ESPP	225,832	—	289	—	—	289
Issuance of common stock for settlement of RSUs	247,877	—	—	—	—	—
Unrealized loss on marketable debt securities	—	—	—	(384)	—	(384)
Stock-based compensation	—	—	6,597	—	—	6,597
Net loss	—	—	—	—	(93,092)	(93,092)
Balance as of December 31, 2022	**48,894,973**	**$49**	**$807,938**	**$(803)**	**$(724,520)**	**$82,664**

See Accompanying Notes to the Consolidated Financial Statements

ASSEMBLY BIOSCIENCES, INC.
CONSOLIDATED STATEMENTS OF CASH FLOWS
(In thousands)

	Year Ended December 31,	
	2022	**2021**
Cash flows from operating activities		
Net loss	$ (93,092)	$ (129,855)
Adjustments to reconcile net loss to net cash used in operating activities:		
Impairment of goodwill and indefinite-lived intangible asset	—	41,638
Depreciation and amortization	498	466
Stock-based compensation	6,593	5,237
Net amortization of investments in marketable debt securities	155	586
Non-cash rent expense	3,505	3,840
Deferred income tax benefit	—	(2,531)
Loss on disposal of property and equipment	—	1,624
Gain on the sale of Microbiome assets	—	(3,000)
Changes in operating assets and liabilities:		
Accounts receivable from collaboration	(608)	894
Prepaid expenses and other current assets	1,328	1,109
Other assets	814	4,689
Accounts payable	(166)	(1,939)
Accrued research and development expenses	(278)	(1,044)
Other accrued expenses	458	(5,070)
Deferred revenue	—	(6,254)
Operating lease liabilities	(3,670)	(3,786)
Net cash used in operating activities	(84,463)	(93,396)
Cash flows from investing activities		
Proceeds from maturities of marketable securities	88,000	175,200
Proceeds from sale of marketable securities	28,825	12,500
Proceeds from the sale of Microbiome assets	1,500	1,500
Purchases of property and equipment	(102)	(3,096)
Purchases of marketable securities	(27,583)	(160,446)
Proceeds from sale of property and equipment	—	857
Net cash provided by investing activities	90,640	26,515
Cash flows from financing activities		
Proceeds from the issuance of common stock under ATM equity offering program, net of issuance costs	325	52,806
Proceeds from the issuance of common stock under ESPP	289	258
Net cash provided by financing activities	614	53,064
Net increase (decrease) in cash and cash equivalents	6,791	(13,817)
Cash and cash equivalents at the beginning of the period	45,627	59,444
Cash and cash equivalents at the end of the period	**$ 52,418**	**$ 45,627**
Supplemental non-cash investing and financing activities		
Operating lease liabilities arising from obtaining ROU assets	$ 171	$ 126
Remeasurement of lease liabilities arising from modification of ROU assets	$ —	$ (788)
Receivable from sale of Microbiome assets included in prepaid expenses and other current assets	$ —	$ (1,500)

See Accompanying Notes to the Consolidated Financial Statements

Note 1 - Nature of Business

Overview

Assembly Biosciences, Inc., together with its subsidiaries (Assembly or the Company), incorporated in Delaware in October 2005, is a biopharmaceutical company advancing clinical candidates for the treatment of chronic hepatitis B virus (HBV) infection, an early-stage development program targeting high-recurrence genital herpes and research programs focused on the discovery of novel antivirals to treat viral diseases, including hepatitis delta virus (HDV), herpes simplex virus type 2 (HSV-2) and transplant related herpesviruses. The Company operates in one segment and is headquartered in South San Francisco, California. Prior to the Company's wind-down of its Microbiome program in January 2021, the Company also had operations in Connecticut.

Liquidity

The Company has not derived any revenue from product sales to date and currently has no approved products. Once a product has been developed, it will need to be approved for sale by the U.S. Food and Drug Administration (FDA) or an applicable foreign regulatory agency. Since inception, the Company's operations have been financed primarily through the sale of equity securities, the proceeds from the exercise of warrants and stock options, the issuance of debt, and upfront payments related to collaboration agreements. The Company has incurred losses from operations since inception and expects to continue to incur substantial losses for the next several years as it continues its product development efforts. Management believes the Company currently has sufficient funds to meet its operating requirements for at least the next twelve months following the date that these consolidated financial statements are issued. If the Company cannot generate significant cash from its operations, it intends to obtain any additional funding it requires through strategic relationships, public or private equity or debt financings, grants or other arrangements. The Company cannot assure such funding will be available on reasonable terms, if at all. Market volatility, inflation or other factors could also adversely impact the Company's ability to access capital when and as needed.

If the Company is unable to secure additional sources of funding, generate revenue from collaborations, or receive full and timely collections of amounts due, it may be necessary to significantly reduce the current rate of spending through reductions in staff and delaying, scaling back, or stopping certain research and development programs, including more costly clinical trials.

Note 2 - Summary of Significant Accounting Policies and Recent Accounting Pronouncements

Basis of Presentation

These consolidated financial statements have been prepared in accordance with accounting principles generally accepted in the United States (U.S. GAAP) and include the accounts of the Company and its wholly owned subsidiaries. All intercompany balances and transactions have been eliminated in consolidation.

Use of Estimates

The preparation of consolidated financial statements in conformity with U.S. GAAP requires management to make estimates and assumptions that may affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and reported amounts of expenses during the reporting period. Actual results could differ from those estimates.

Significant estimates inherent in the preparation of the accompanying consolidated financial statements include estimates of costs incurred but not yet invoiced for research and development accruals as well as the estimated fair value of the Company's indefinite-lived intangible asset and the estimated fair value of the Company's reporting unit for purposes of evaluating goodwill impairment, both of which were fully impaired in 2021.

The Company's estimates could be affected by external conditions, including those unique to the Company and general economic conditions. It is reasonably possible that these external factors could have an effect on the Company's estimates and could cause actual results to differ from those estimates and assumptions.

Other Risks and Uncertainties

The Company relies on contract research organizations (CROs), including one located in Ukraine which shut down operations due to Russia's invasion. Though this CRO has resumed operations, the Company has reallocated certain work to other global CROs in case the CRO shuts down operations again.

U.S. and global financial markets have experienced volatility and disruption due to other macroeconomic and geopolitical events such as rising inflation, the risk of a recession, the ongoing conflict between Russia and Ukraine, as well as the ongoing impact of the COVID-19 pandemic. The Company cannot predict at this time to what extent, if at all, it and its employees, CROs, vendors and/or collaborators could potentially be negatively impacted by these events.

Cash and Cash Equivalents

All highly liquid investments, including money market funds, with original maturities of three months or less at the time of purchase are considered to be cash equivalents. All of the Company's cash equivalents have liquid markets and high credit ratings. The Company maintains its cash in bank deposits and other accounts, the balances of which, at times as of and during the years ended December 31, 2022 and 2021, exceed federally insured limits.

Investments in Marketable Securities

The Company invests its excess cash in debt securities with high credit ratings including but not limited to money market funds classified as cash equivalents, asset backed securities, securities issued by the U.S. government and its agencies, corporate debt securities and commercial paper. The Company has designated its investments in marketable securities as available-for-sale and measures these securities at their respective fair values. Marketable securities are classified as short-term or long-term based on the maturity date and their availability to meet current operating requirements. Marketable securities that mature in one year or less from the consolidated balance sheet date are classified as short-term available-for-sale securities, while marketable securities with maturities in one year or beyond one year from the consolidated balance sheet date are classified as long-term.

Securities that are classified as available-for-sale are measured at fair value with temporary unrealized gains and losses reported in other comprehensive loss, and as a component of stockholders' equity until their disposition. The Company reviews all available-for-sale securities at each period end to determine if they remain available-for-sale based on their current intent and ability to sell the security if it is required to do so. Realized gains and losses from the sale of marketable securities, if any, are calculated using the specific-identification method.

Marketable securities are subject to a periodic impairment review. The Company may recognize an impairment charge when a decline in the fair value of investments below the cost basis is determined to be other-than-temporary. In determining whether a decline in market value is other-than-temporary, various factors are considered, including the cause, duration of time and severity of the impairment, any adverse changes in the investees' financial condition, and the Company's intent and ability to hold the security for a period of time sufficient to allow for an anticipated recovery in market value. To date, there have been no declines in value deemed to be other than temporary for any of the Company's investments in marketable securities.

Goodwill and Indefinite-Lived Intangible Asset

Prior to their full impairment in 2021, goodwill and indefinite-lived intangible assets were reviewed for impairment at least annually in the fourth quarter, and more frequently if events or other changes in circumstances indicated that the carrying amount of the assets may not have been recoverable.

Goodwill

The difference between the purchase price and the fair value of assets acquired and liabilities assumed in a business combination is allocated to goodwill. Goodwill was evaluated for impairment on an annual basis as of October 1, and more frequently if indicators were present or changes in circumstances suggested impairment may have existed. In performing each annual impairment assessment and any interim impairment assessment, the Company determined if it should qualitatively assess whether it was more likely than not the fair value of goodwill was less than its carrying amount (the qualitative impairment test). If the Company concluded it was more likely than not the fair value of the

reporting unit was less than its carrying amount, or elected not to use the qualitative impairment test, a quantitative impairment test was performed. The Company's annual or interim quantitative impairment testing was performed by comparing the estimated fair value of the reporting unit to its carrying value. An impairment charge was recognized for the amount by which the carrying amount exceeded the reporting unit's fair value, not to exceed the carrying value of goodwill.

Indefinite-Lived Intangible Asset

The Company's indefinite-lived intangible asset consisted of in-process research and development (IPR&D) associated with small molecule core inhibitors that directly target and allosterically inhibit core protein functions associated with HBV which were acquired with the acquisition of Assembly Pharmaceutics, Inc. in 2014. IPR&D represented the fair value assigned to incomplete research projects the Company acquired through a business combination which, at the time of acquisition, had not reached technological feasibility, regardless of whether they had alternative future use. The primary basis for determining the technological feasibility or completion of these projects was obtaining regulatory approval to market the underlying products in an applicable geographic region. The Company classified IPR&D acquired in a business combination as an indefinite-lived intangible asset until the associated research and development efforts were either completed or abandoned. Upon completion of the associated research and development efforts, the Company would perform a final test for impairment and would determine the useful life of the technology and would begin amortizing the assets to reflect their use over their remaining lives. Upon permanent abandonment, the Company would write-off the remaining carrying amount of the associated IPR&D intangible asset.

Indefinite-lived intangible assets were not amortized, but instead were reviewed for impairment at least annually, or more frequently if events occurred or circumstances changed that would indicate the carrying amount may be impaired. In performing each annual impairment assessment and any interim impairment assessment, the Company determined if it should qualitatively assess whether it was more likely than not the fair value of its IPR&D asset was less than its carrying amount (the qualitative impairment test). If the Company concluded that was the case, or elected not to use the qualitative impairment test, the Company would proceed with quantitatively determining the fair value of the IPR&D asset and compared its fair value to its carrying value to determine the amount of impairment, if any (the quantitative impairment test).

In performing the qualitative impairment test, the Company considered the results of the most recent quantitative impairment test and identified the most relevant drivers of the fair value for the IPR&D asset. The most relevant drivers of fair value identified were consistent with the assumptions used in the quantitative estimate of the IPR&D asset. Using these drivers of fair value, the Company identified events and circumstances which may have had an effect on the fair value of the IPR&D asset since the last time the IPR&D's fair value was quantitatively determined. The Company then weighed these factors to determine and conclude if it was not more likely than not the IPR&D asset was impaired. If it was more likely than not the IPR&D asset was impaired, the Company proceeded with quantitatively determining the fair value of the IPR&D asset.

When performing the quantitative impairment test, the Company used the income approach to determine the fair value of its IPR&D asset. This approach calculates fair value by estimating the after-tax cash flows attributable to an in-process project over its useful life and then discounting these after-tax cash flows back to a present value. This estimate included judgmental assumptions regarding the estimates that market participants would make in evaluating the IPR&D asset, including the probability of successfully completing clinical trials and obtaining regulatory approval to market the IPR&D asset, the timing of and the expected costs to complete IPR&D projects, future net cash flows from potential drug sales, which were based on estimates of the sales price of the drug, the size of the patient population and cure rate, the Company's competitive position in the marketplace, and appropriate discount and tax rates. Any

impairment to be recorded was calculated as the difference between the estimated fair value and the carrying value of the IPR&D asset on the Company's consolidated balance sheet.

Leases

All of the Company's leases are operating leases for facilities and equipment. The Company recognizes a lease asset for its right to use the underlying asset and a lease liability for the corresponding lease obligation. The Company determines whether an arrangement is or contains a lease at contract inception. Operating leases with a duration greater than one year are included in operating lease ROU assets, operating lease liabilities - short-term, and operating lease liabilities - long-term in the Company's consolidated balance sheets. Operating lease ROU assets and liabilities are recognized at the lease commencement date based on the present value of lease payments over the lease term. In determining the net present value of lease payments, the Company uses its incremental borrowing rate based on the information available at the lease commencement date. The incremental borrowing rate represents the interest rate the Company would incur at lease commencement to borrow an amount equal to the lease payments on a collateralized basis over the term of a lease. The Company considers a lease term to be the noncancelable period that it has the right to use the underlying asset, including any periods where it is reasonably assured the Company will exercise the option to extend the contract. Periods covered by an option to extend are included in the lease term if the lessor controls the exercise of that option.

The operating lease ROU assets also include any lease payments made and exclude lease incentives. Lease expense is recognized on a straight-line basis over the expected lease term. Variable lease expenses are recorded when incurred. The Company has elected not to separate lease and non-lease components for its leased assets and accounts for all lease and non-lease components of its agreements as a single lease component.

Impairment of Long-Lived Assets

The Company monitors the carrying value of long-lived assets, including ROU operating lease assets, for potential impairment and tests the recoverability of such assets whenever events or changes in circumstances indicate that the carrying amounts may not be recoverable. If a change in circumstance occurs, the Company performs a test of recoverability by comparing the carrying value of the asset or asset group to its undiscounted expected future cash flows. If cash flows cannot be separately and independently identified for a single asset, the Company will determine whether impairment has occurred for the group of assets for which the Company can identify the projected cash flows. If the carrying values are in excess of undiscounted expected future cash flows, the Company measures any impairment by comparing the fair value of the asset or asset group to its carrying value. There were no indicators of impairment of long-lived assets during the years ended December 31, 2022 and 2021.

Property and Equipment, Net

Property and equipment are stated at cost and consist of lab and office equipment and leasehold improvements. The Company records depreciation under the straight-line method over the estimated useful lives of its property and equipment ranging from three to seven years.

Leasehold improvements are amortized over the remaining terms of the respective leases or the estimated useful life of the leasehold improvements, whichever is less. Maintenance and repair costs are expensed as incurred.

Fair Value Measurements

The Company follows accounting guidance on fair value measurements for financial instruments measured on a recurring basis, as well as for certain assets and liabilities that are initially recorded at their estimated fair values. Fair value is defined as the exit price, or the amount that would be received from selling an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date. The Company uses the following three-level hierarchy that maximizes the use of observable inputs and minimizes the use of unobservable inputs to value its financial instruments:

Level 1: Observable inputs such as unadjusted quoted prices in active markets for identical instruments.

Level 2: Quoted prices for similar instruments that are directly or indirectly observable in the marketplace.

Level 3: Significant unobservable inputs which are supported by little or no market activity and that are financial instruments whose values are determined using pricing models, discounted cash flow methodologies, or similar

techniques, as well as instruments for which the determination of fair value requires significant judgment or estimation.

Financial instruments measured at fair value are classified in their entirety based on the lowest level of input that is significant to the fair value measurement. The assessment of the significance of a particular input to the fair value measurement in its entirety requires the Company to make judgments and consider factors specific to the asset or liability. The use of different assumptions and/or estimation methodologies may have a material effect on estimated fair values. Accordingly, the fair value estimates disclosed or initial amounts recorded may not be indicative of the amount the Company or holders of the instruments could realize in a current market exchange.

The carrying amounts of cash equivalents and marketable securities approximate their fair value based upon quoted market prices. Certain of the Company's financial instruments are not measured at fair value on a recurring basis but are recorded at amounts which approximate their fair value due to their liquid or short-term nature, such as cash, accounts receivable, accounts payable and accrued expenses.

The following tables present the fair value of the Company's financial assets measured at fair value on a recurring basis using the above input categories (in thousands):

	December 31, 2022			
	Level 1	Level 2	Level 3	Fair Value
Cash equivalents				
Money market fund	$ 49,676	$ —	$ —	$ 49,676
Total cash equivalents	49,676	—	—	49,676
Short-term marketable securities				
U.S. and foreign corporate debt securities	—	18,597	—	18,597
U.S. treasury securities	—	11,744	—	11,744
U.S. and foreign commercial paper	—	8,851	—	8,851
Total short-term marketable securities	—	39,192	—	39,192
Total assets measured at fair value	$ 49,676	$ 39,192	$ —	$ 88,868

	December 31, 2021			
	Level 1	Level 2	Level 3	Fair Value
Cash equivalents				
Money market fund	$ 42,507	$ —	$ —	$ 42,507
Total cash equivalents	42,507	—	—	42,507
Short-term marketable securities				
U.S. and foreign corporate debt securities	—	7,013	—	7,013
Asset-backed securities	—	29,059	—	29,059
U.S. and foreign commercial paper	—	64,928	—	64,928
Total short-term marketable securities	—	101,000	—	101,000
Long-term marketable securities				
U.S. and foreign corporate debt securities	—	19,043	—	19,043
U.S. treasury securities	—	8,929	—	8,929
Total long-term marketable securities	—	27,972	—	27,972
Total assets measured at fair value	$ 42,507	$ 128,972	$ —	$ 171,479

Money market funds are highly liquid and actively traded marketable securities that generally transact at a stable $1.00 net asset value representing its estimated fair value. The Company estimates the fair value of its U.S. and foreign corporate debt securities, asset backed securities, U.S. treasury securities and U.S. and foreign commercial paper by taking into consideration valuations obtained from third-party pricing services. The pricing services utilize industry standard valuation models, including both income and market-based approaches, for which all significant inputs are observable, either directly or indirectly, to estimate fair value. These inputs include reported trades of and broker/dealer quotes on the same or similar securities, issuer credit spreads; benchmark securities; prepayment/default projections based on historical data; and other observable inputs.

The Company recognized an impairment charge of $41.6 million for its goodwill and indefinite-lived asset in 2021. The Company considered the fair value used to determine the impairment charge to be a Level 3 measurement. See additional discussion relating to the Company's impairment of goodwill and indefinite-lived asset in Note 6.

There have been no transfers between Level 1, Level 2 or Level 3 for any of the periods presented. See Note 3 for further information regarding the carrying value of the Company's investments in marketable securities.

Revenue Recognition and Accounts Receivable from Collaboration

The Company analyzes its collaboration arrangements to assess whether such arrangements, or transactions between arrangement participants, involve joint operating activities performed by parties that are both active participants in the activities and exposed to significant risks and rewards dependent on the commercial success of such activities or are more akin to a vendor-customer relationship. In making this evaluation, the Company considers whether the activities of the collaboration are considered to be distinct and deemed to be within the scope of the collaborative arrangement accounting standard and those that are more reflective of a vendor-customer relationship and, therefore, within the scope of the revenue with contracts with customers accounting standard. This assessment is performed throughout the life of the arrangement based on changes in the responsibilities of all parties in the arrangement.

For elements of collaboration arrangements that are not accounted for pursuant to the revenue from contracts with customers accounting standard, an appropriate recognition method is determined and applied consistently, generally by analogy to the revenue from contracts with customers accounting standard. Amounts related to transactions with a counterparty in a collaborative arrangement that is not a customer are presented as collaboration revenue and on a separate line item from revenue recognized from contracts with customers, if any, in the Company's consolidated statements of operations and comprehensive loss.

Under certain collaborative arrangements, the Company has been reimbursed for a portion of its research and development expenses or participates in the cost-sharing of such research and development expenses. Such reimbursements and cost-sharing arrangements are reflected as a reduction of research and development expense in the Company's consolidated statements of operations and comprehensive loss, as the Company does not consider performing these activities for reimbursement to be a part of its ongoing major or central operations.

For arrangements or transactions between arrangement participants determined to be within the scope of the contracts with customers accounting standard, the Company evaluates the term of the arrangement and recognizes revenue when the customer obtains control of promised goods or services in a contract for an amount that reflects the consideration the Company expects to receive in exchange for those goods or services. For contracts with customers, the Company applies the following five-step model in order to determine this amount: (1) identification of the promised goods or services in the contract; (2) determination of whether the promised goods or services are performance obligations, including whether they are distinct in the context of the contract; (3) measurement of the transaction price, including the constraint on variable consideration; (4) allocation of the transaction price to the performance obligations; and (5) recognition of revenue when (or as) the Company satisfies each performance obligation.

The Company has provided standard indemnification and protection of licensed intellectual property for its customer. These provisions are part of assurance that the licenses meet the agreements, representations and are not obligations to provide goods or services.

The Company only applies the five-step model to contracts when it is probable the Company will collect the consideration it is entitled to in exchange for the goods or services it transfers to the customer. As part of the accounting for contracts with customers, the Company must develop assumptions that require judgment to determine the estimated relative standalone selling price (SSP) of each performance obligation identified in the contract. The Company then allocates the total transaction price to each performance obligation based on the SSP of each performance obligation.

The Company recognizes the amount of the transaction price that is allocated to the respective performance obligation when the performance obligation is satisfied or as it is satisfied as revenue.

Upfront License Fees

If a license to the Company's intellectual property is determined to be distinct from the other performance obligations identified in the arrangement, the Company recognizes revenues from nonrefundable, upfront license fees based on the relative value prescribed to the license compared to the total value of the arrangement. The revenue is recognized when the license is transferred to the collaborator and the collaborator is able to use and benefit from the license. For licenses that are not distinct from other obligations identified in the arrangement, the Company utilizes judgment to assess the nature of the combined performance obligation to determine whether the combined performance obligation is satisfied over time or at a point in time. If the combined performance obligation is satisfied over time, the Company applies an appropriate method of measuring progress for purposes of recognizing revenue from nonrefundable, upfront license fees. The Company evaluates the measure of progress each reporting period and, if necessary, adjusts the measure of performance and related revenue recognition.

Development and Regulatory Milestone Payments

Depending on facts and circumstances, the Company may record revenues from certain milestones in a reporting period before the milestone is achieved if the Company concludes achievement of the milestone is probable and recognition of revenue related to the milestone will not result in a significant reversal in amounts recognized in future periods. The Company records a corresponding contract asset when this conclusion is reached. Milestone payments that have not been included in the transaction price to date are fully constrained. The Company re-evaluates the probability of achievement of such milestones and any related constraint each reporting period. The Company adjusts its estimate of the overall transaction price, including the amount of collaborative revenue that was recorded, if necessary.

Sales-based Milestone and Royalty Payments

The Company's customer may be required to pay the Company sales-based milestone payments or royalties on future sales of commercial products. The Company recognizes revenues related to sales-based milestone and royalty payments upon the later to occur of (i) achievement of the collaborator's underlying sales or (ii) satisfaction of any performance obligation(s) related to these sales, in each case assuming the Company's licensed intellectual property is deemed to be the predominant item to which the sales-based milestones and/or royalties relate.

The Company receives payments from its customer based on billing schedules established in the contract. Upfront payments and fees are recorded as deferred revenue upon receipt or when due until the Company performs its obligations under the arrangement. If the related performance obligation is expected to be satisfied within the next twelve months, these amounts will be classified in current liabilities. The Company recognizes a contract asset relating to its conditional right to consideration that is not subject to a constraint. Amounts are recorded as accounts receivable when the Company's right to consideration is unconditional.

A net contract asset or liability is presented for each contract with a customer. The Company does not assess whether a contract has a significant financing component if the expectation at contract inception is such that the period between payment by the customer and the transfer of the promised goods or services to the customer will be one year or less.

At December 31, 2022 and 2021, all accounts receivable from collaboration are deemed collectible.

Contract Liabilities

The following tables present changes in the Company's contract liabilities (in thousands):

	Balance at Beginning of Period	Additions	Deductions	Balance at End of Period
Year Ended December 31, 2022				
Contract liabilities:				
Deferred revenue	$ 2,733	$ —	$ —	$ 2,733

	Balance at Beginning of Period	Additions	Deductions	Balance at End of Period
Year Ended December 31, 2021				
Contract liabilities:				
Deferred revenue	$ 8,987	$ —	$ (6,254)	$ 2,733

	Year Ended December 31,	
	2022	2021
Collaboration revenue recognized in the period from		
Amounts included in deferred revenue at the beginning of the period	$ —	$ 6,254
Performance obligations satisfied in previous period	$ —	$ —

Stock-Based Compensation

The Company measures stock-based compensation to employees, consultants, Board members, and non-employees at fair value on the grant date of the award. The fair value of RSUs is determined based on the number of shares granted and the quoted market price of the Company's common stock on the date of grant. If stock-based awards are granted in contemplation of or shortly before a planned release of material nonpublic information, and such information is expected to result in a material increase in the Company's share price, the Company considers whether an adjustment to the observable market price is required when estimating fair values. Compensation cost is recognized as expense on a straight-line basis over the requisite service period of the award. Stock-based awards with graded vesting schedules are recognized using the accelerated attribution method on a straight-line basis over the requisite service period for each separately vesting portion of the award. For awards that have a performance condition, compensation cost is measured based on the fair value of the award on the grant date, the date performance targets are established, and is expensed over the requisite service period for each separately vesting tranche when achievement of the performance condition becomes probable. The Company assesses the probability of the performance conditions being met on a continuous basis. For awards that have a market condition, compensation cost is measured based on the grant-date fair value of the award and is expensed over the derived service period regardless of whether the underlying market condition is met. Forfeitures are recognized when they occur.

The Company estimates the fair value of stock option grants that do not contain market-based vesting conditions using the Black-Scholes option pricing model. The assumptions used in estimating the fair value of these awards, such as expected term, expected dividend yield, volatility and risk-free interest rate, represent management's best estimates and involve inherent uncertainties and the application of management's judgment. The Company uses the Monte-Carlo model to calculate the fair value on the date of grant of awards which contain market-based vesting conditions. This pricing model uses multiple simulations to evaluate the probability of achieving the market condition to calculate the fair value of the awards which includes the recent market price and volatility of the Company's shares. The Company is also required to make estimates as to the probability of achieving the specific performance conditions. If actual results are not consistent with the Company's assumptions and judgments used in making these estimates, the Company may be required to increase or decrease compensation expense, which could be material to the Company's consolidated results of operations.

Research and Development Expense and Accruals

Research and development costs include personnel-related costs, outside contracted services including clinical study costs, facilities costs, fees paid to consultants, milestone payments prior to FDA approval, license fees prior to FDA

approval, professional services, travel costs, dues and subscriptions, depreciation and materials used in clinical trials and research and development and costs incurred under the Company's collaboration agreements. Research and development costs are expensed as incurred unless there is an alternative future use in other research and development projects. Payments made prior to the receipt of goods or services to be used in research and development are capitalized until the goods or services are received. Such payments are evaluated for current or long-term classification based on when they will be realized or consumed.

The Company records expenses related to clinical studies and manufacturing development activities based on its estimates of the services received and efforts expended pursuant to contracts with multiple contract research organizations and manufacturing vendors that conduct and manage these activities on its behalf. The financial terms of these agreements are subject to negotiation, vary from contract to contract, and may result in uneven payment flows. There may be instances in which payments made to the Company's vendors will exceed the level of services provided and result in a prepayment of the expense. Payments under some of these contracts depend on factors such as the successful enrollment of subjects and the completion of clinical study milestones. In amortizing or accruing service fees, the Company estimates the time period over which services will be performed, enrollment of subjects, number of sites activated and the level of effort expended in each period. If the actual timing of the performance of services or the level of effort varies from the Company's estimate, the Company will adjust the accrued or prepaid expense balance accordingly. To date, there have been no material differences from the Company's estimates to the amounts actually incurred.

The Company has entered and may continue to enter into license agreements to access and utilize certain technology. In each case, the Company evaluates if the license agreement results in the acquisition of an asset or a business. To date, none of the Company's license agreements have been considered to be acquisitions of businesses. For asset acquisitions, the upfront payments to acquire such licenses, as well as any future milestone payments, are immediately recognized as research and development expense when paid, provided there is no alternative future use of the rights in other research and development projects. These license agreements may also include contingent consideration in the form of cash payments to be made for future milestone events. The Company assesses whether such contingent consideration meets the definition of a derivative and to date the Company has determined that such contingent consideration are not derivatives.

Restructuring Charges

The Company recognizes restructuring charges related to reorganization plans that have been committed to by management and when liabilities have been incurred. In connection with these activities, the Company records restructuring charges at fair value for (1) contractual employee termination benefits when obligations are associated to services already rendered, rights to such benefits have vested, and payment of benefits is probable and can be reasonably estimated, (2) one-time employee termination benefits when management has committed to a plan of termination, the plan identifies the employees and their expected termination dates, the details of termination benefits are complete, it is unlikely changes to the plan will be made or the plan will be withdrawn and communication to such employees has occurred, and (3) contract termination costs when a contract is terminated before the end of its term.

One-time employee termination benefits are recognized in their entirety when communication has occurred, and future services are not required. If future services are required, the costs are recorded ratably over the remaining period of service. Contract termination costs to be incurred over the remaining contract term without economic benefit are recorded in their entirety when the contract is canceled.

The recognition of restructuring charges requires the Company to make certain judgments and estimates regarding the nature, timing and amount of costs associated with the reorganization plan. To the extent the Company's actual results differ from its estimates and assumptions, the Company may be required to revise the estimates of future accrued restructuring liabilities, requiring the recognition of additional restructuring charges or the reduction of accrued restructuring liabilities already recognized. Such changes to previously estimated amounts may be material to the consolidated financial statements. Changes in the estimates of the restructuring charges are recorded in the period the change is determined. During the years ended December 31, 2022 and 2021, changes to previous estimates for restructuring charges were not material.

At the end of each reporting period, the Company evaluates the remaining accrued restructuring balances to ensure that no excess accruals are retained, and the utilization of the provisions are for their intended purpose in accordance with developed restructuring plans.

For gains and losses on the derecognition of nonfinancial assets the Company determines if a contract exists, identifies the distinct non-financial assets, and determines when control transfers and, therefore, when to derecognize the asset. Additionally, the Company applies the measurement principles of revenue from contracts with customers within U.S. GAAP to determine the amount of consideration to include in the calculation of the gain or loss for the non-financial asset. Any gains or losses have been included within research and development expenses.

Variable Interest Entities

The Company reviews agreements it enters into with third party entities, pursuant to which it may have a variable interest in the entity, in order to determine if the entity is a variable interest entity (VIE). If the entity is a VIE, the Company assesses whether or not it is the primary beneficiary of that entity. In determining whether the Company is the primary beneficiary of an entity, the Company applies a qualitative approach that determines whether it has both (1) the power to direct the economically significant activities of the entity and (2) the obligation to absorb losses of, or the right to receive benefits from, the entity that could potentially be significant to that entity. If the Company were to determine it is the primary beneficiary of a VIE, the Company would consolidate the statements of operations and financial condition of the VIE into its consolidated financial statements.

The Company's determination about whether it should consolidate such VIEs is made continuously as changes to existing relationships or future transactions may result in a consolidation event.

Income Taxes

The Company records income taxes using the asset and liability method. Deferred income tax assets and liabilities are recognized for the future tax effects attributable to temporary differences between the financial statement carrying amounts of existing assets and liabilities and their respective income tax bases, and operating loss and tax credit carryforwards. The effect of a change in tax rates on deferred tax assets and liabilities is recognized in income in the period that includes the enactment date. The Company establishes a valuation allowance if it is more likely than not that the deferred tax assets will not be realized based on an evaluation of objective verifiable evidence. For tax positions that are more likely than not of being sustained upon audit, the Company recognizes the largest amount of the benefit that is greater than 50% likely of being realized. For tax positions that are not more likely than not of being sustained upon audit, the Company does not recognize any portion of the benefit.

The Company recognizes and measures uncertain tax positions using a two-step approach set forth in authoritative guidance. The first step is to evaluate the tax position taken or expected to be taken by determining whether the weight of available evidence indicates that it is more likely than not that the tax position will be sustained in an audit, including resolution of any related appeals or litigation processes. The second step is to measure the tax benefit as the largest amount that is more than 50% likely to be realized upon ultimate settlement. Significant judgment is required to evaluate uncertain tax positions. The Company evaluates uncertain tax positions on a regular basis. The evaluations are based on a number of factors, including changes in facts and circumstances, changes in tax law, correspondence with tax authorities during the course of the audit, and effective settlement of audit issues. The provision for income taxes includes the effects of any accruals which the Company believes are appropriate. It is the Company's policy to recognize interest and penalties related to income tax matters in income tax expense. No interest or penalties related to uncertain tax positions has been incurred or accrued for any periods presented.

In June 2020, Assembly Bill 85 (A.B. 85) was signed into California law. A.B. 85 provides for a three-year suspension of the use of net operating losses for medium and large businesses and a three-year cap on the use of business incentive tax credits to offset no more than $5.0 million of tax per year. A.B. 85 suspends the use of net operating losses for taxable years 2020, 2021 and 2022 for certain taxpayers with taxable income of $1.0 million or more. The carryover period for any net operating losses that are suspended under this provision will be extended. A.B. 85 also requires that business incentive tax credits including carryovers may not reduce the applicable tax by more than $5.0 million for taxable years 2020, 2021 and 2022. On February 9, 2022, Senate Bill No. 113 was enacted that removed the limitations on the use of NOLs and the cap on the business incentive tax credits that were suspended in accordance with AB 85 effective for tax year 2022.

In March 2021, the American Rescue Plan (H.R. 1319) was signed into law. This legislation extends and enhances a number of current-law tax incentives for businesses, but also expands the definition of a "covered employee" as defined by Section 162(m)(1) of the Internal Revenue Code.

Effective January 1, 2022, a provision of the Tax Cuts and Jobs Act (TCJA) took effect creating a significant change to the treatment of research and experimental expenditures under Section 174 of the Internal Revenue Code (Sec. 174 expenses). Historically, businesses have had the option of deducting Sec. 174 expenses in the year incurred or capitalizing and amortizing the costs over five years. The new TCJA provision, however, eliminates this option and will require Sec. 174 expenses associated with research conducted in the United States to be capitalized and amortized over a five-year period. For expenses associated with research outside of the United States, Sec. 174 expenses are required to be capitalized and amortized over a 15-year period.

The A.B. 85, H.R. 1319 and TCJA provision did not have a material impact on the Company's consolidated financial statements.

In August 2022, the Inflation Reduction Act (IRA) was enacted into law. The IRA establishes a 15% corporate alternative minimum tax on corporations whose average annual adjusted financial statement income during the most recently completed three-year period exceeds $1 billion and a 1% excise tax on stock repurchases made by certain publicly traded U.S. corporations. These provisions are effective for tax years beginning after December 31, 2022. The Company does not currently qualify for the corporate alternative minimum tax, and these provisions are not expected to have a material impact to the Company's consolidated financial statements.

Net Loss per Share

Basic net loss per common share excludes dilution and is computed by dividing net loss by the weighted average number of common shares outstanding during the period. Diluted net loss per common share reflects the potential dilution that could occur if securities or other contracts to issue common stock were exercised or converted into common stock or resulted in the issuance of common stock that then shared in the earnings of the entity unless inclusion of such shares would be anti-dilutive. Since the Company has only incurred losses, basic and diluted net loss per share is the same.

A reconciliation of the numerators and the denominators of the basic and diluted net loss per common share computations is as follows (in thousands, except per share amounts):

	Year Ended December 31,	
	2022	2021
Numerator:		
Net loss	$ (93,092)	$ (129,855)
Denominator:		
Weighted average common shares and pre-funded warrants outstanding - basic and diluted	48,409,265	43,280,383
Net loss per share - basic and diluted	$ (1.92)	$ (3.00)

Securities excluded from the computation of diluted loss from per share because including them would have been antidilutive are as follows:

	December 31,	
	2022	2021
Options to purchase common stock	9,090,865	6,161,901
Common stock subject to purchase under ESPP	71,653	78,740
Unvested RSUs	1,699,764	970,339
Total	10,862,282	7,210,980

Comprehensive Loss

Comprehensive loss is comprised of net loss and adjustments for the change in unrealized gains and losses on investments in available-for-sale marketable securities. The Company displays comprehensive loss and its components in the consolidated statements of operations and comprehensive loss, net of tax effects if any.

Concentrations of Risk

Credit Risk

Financial instruments which potentially subject the Company to credit risk consist primarily of cash, cash equivalents and marketable securities. The Company holds these investments in highly rated financial institutions, and, by policy, limits the amounts of credit exposure to any one financial institution. These amounts at times may exceed federally insured limits. The Company has not experienced any credit losses in such accounts and does not believe it is exposed to any significant credit risk on these funds. The Company has no off-balance sheet concentrations of credit risk, such as foreign currency exchange contracts, option contracts or other hedging arrangements.

Supplier Risk

Certain materials and key components the Company utilizes in its operations are obtained through single suppliers. Since the suppliers of key components and materials must be named in a New Drug Application (NDA) filed with the FDA for a product, significant delays can occur if the qualification of a new supplier is required. If delivery of material from the Company's suppliers were interrupted for any reason, the Company may be unable to supply any of its product candidates for clinical trials.

Accounting Pronouncements to Be Adopted

In June 2016, the Financial Accounting Standards Board (the FASB) issued ASU 2016-13, *Financial Instruments – Credit Losses: Measurement of Credit Losses on Financial Instruments* (ASU 2016-13), which requires that expected credit losses relating to financial assets measured on an amortized cost basis and available-for-sale debt securities be recorded through an allowance for credit losses. ASU 2016-13 limits the amount of credit losses to be recognized for available-for-sale debt securities to the amount by which carrying value exceeds fair value and requires the reversal of previously recognized credit losses if fair value increases. In April, May and November 2019, the FASB issued additional amendments to the new guidance related to transition and clarification. In November 2019, the FASB issued ASU 2019-10, *Financial Instruments – Credit Losses (Topic 326)*, *Derivatives and Hedging (Topic 815)*, and *Leases (Topic 842): Effective Dates*, which deferred the effective date of this standard for all entities except SEC filers that are not smaller reporting companies to fiscal years beginning after December 15, 2022, including interim periods within those fiscal years. Early adoption is permitted. The Company does not expect ASU 2016-13 to have a material impact on its consolidated financial statements and related disclosures.

Note 3 - Investments in Marketable Securities

Investments in marketable available-for-sale securities consisted of the following (in thousands):

	December 31, 2022			
	Amortized Cost	Gross Unrealized Gain	Gross Unrealized Loss	Fair Value
Cash equivalents				
Money market fund	$ 49,676	$ —	$ —	$ 49,676
Total cash equivalents	49,676	—	—	49,676
Short-term marketable securities				
U.S. and foreign corporate debt securities	18,903	—	(306)	18,597
U.S. treasury securities	11,968	—	(224)	11,744
U.S. and foreign commercial paper	8,851	—	—	8,851
Total short-term marketable securities	39,722	—	(530)	39,192
Total cash equivalents and marketable securities	$ 89,398	$ —	$ (530)	$ 88,868

	December 31, 2021			
	Amortized Cost	Gross Unrealized Gain	Gross Unrealized Loss	Fair Value
Cash equivalents				
Money market fund	$ 42,507	$ —	$ —	$ 42,507
Total cash equivalents	42,507	—	—	42,507
Short-term marketable securities				
U.S. and foreign corporate debt securities	7,015	—	(2)	7,013
Asset-backed securities	29,097	—	(38)	29,059
U.S. and foreign commercial paper	64,929	—	(1)	64,928
Total short-term marketable securities	101,041	—	(41)	101,000
Long-term marketable securities				
U.S. and foreign corporate debt securities	19,117	—	(74)	19,043
U.S. treasury securities	8,960	—	(31)	8,929
Total long-term marketable securities	28,077	—	(105)	27,972
Total cash equivalents and marketable securities	$ 171,625	$ —	$ (146)	$ 171,479

Short-term marketable securities held as of December 31, 2022 and 2021 had contractual maturities of less than one year. Long-term marketable securities held as of December 31, 2021 had contractual maturities of at least one year but less than two years.

Realized gains and losses for the years ended December 31, 2022 and 2021 were not material. As of December 31, 2022, investments which were in a continuous unrealized loss position for more than 12 months were determined to be temporary. None of the Company's investments had been in a continuous unrealized loss position for more than 12 months as of December 31, 2021. The Company determined it has the ability and intent to hold all marketable securities that have been in a continuous loss position until maturity of recovery and that the gross unrealized losses above were caused by changes in interest rates.

See Note 2 for further information regarding the fair value of the Company's investments in marketable securities.

Note 4 - Property and Equipment, Net

Property and equipment, net consists of the following (in thousands):

	December 31,	
	2022	2021
Lab equipment	102	18
Office equipment	699	699
Leasehold improvement	1,629	1,629
Total property and equipment	2,430	2,346
Less: Accumulated depreciation	(1,687)	(1,207)
Property and equipment, net	$ 743	$ 1,139

Depreciation expense was $0.5 million for each of the years ended December 31, 2022 and 2021 and was recorded in both research and development expense and general and administrative expense in the consolidated statements of operations and comprehensive loss.

Note 5 – Other Accrued Expenses

Other accrued expenses consist of the following (in thousands):

	December 31,	
	2022	2021
Accrued expenses:		
Accrued compensation	$ 6,228	$ 6,426
Accrued restructuring charges	599	—
Accrued professional fees and other	490	437
Total accrued expenses	$ 7,317	$ 6,863

Note 6 – Goodwill and Indefinite-Lived Intangible Asset Impairment

Goodwill

In 2021, the Company recognized a full impairment of goodwill after performing a quantitative impairment assessment for its single reporting unit in 2021 due to a sustained decline in its market capitalization, an increase in negative economic outlook for biotech markets and a fourth quarter unfavorable clinical trial result for a competitor's curative combination therapy for HBV infection. The Company estimated and reconciled the fair value of its reporting unit using both a market approach, utilizing the Company's market capitalization adjusted for an estimated control premium, and the income approach, discounting future cash flows based on management's expectations of timelines to complete clinical trials, regulatory and commercial probabilities of technical success as well as future earnings forecast. Based on this analysis, and after completing an impairment assessment of its indefinite-lived and long-lived assets, the Company concluded the fair value of its single reporting unit was less than its carrying value and therefore recognized a goodwill impairment charge of $12.6 million during the year ended December 31, 2021. The goodwill impairment charge is reflected in impairment of goodwill and indefinite-lived intangible asset in the consolidated statements of operations and comprehensive loss for the year ended December 31, 2021.

Indefinite-Lived Intangible Asset

In 2021, the Company recognized a full impairment of its indefinite-lived intangible asset after completing a quantitative impairment test for its IPR&D asset associated with the Assembly Pharmaceuticals, Inc. acquisition prior to the goodwill impairment test. The Company utilized the discounted cash flow model of the income approach and determined the carrying value of its IPR&D asset was fully impaired resulting in an impairment charge of $29.0 million during the year ended December 31, 2021. This was primarily driven by a higher discount rate applied to future cash flows based on a market participant's view of increased risk associated with a negative economic outlook for biotech markets and a fourth quarter unfavorable clinical trial result for a competitor's curative combination therapy for HBV infection. More significant assumptions inherent in the development of the model included the estimated annual cash flows, particularly net revenues, the appropriate discount rate to select in order to measure the risk inherent in the future cash flows, cost to complete the IPR&D project as well as other factors. The impairment charge recorded is reflected in impairment of goodwill and indefinite-lived intangible asset in the consolidated statements of operations and comprehensive loss for the year ended December 31, 2021.

Note 7 – Restructurings

In December 2020, the Company and its Board of Directors approved the wind-down of its Microbiome program, which was completed in 2021. The Company incurred cumulative restructuring costs of $4.3 million in connection with the wind-down of its Microbiome program, $3.2 million of which relate to asset impairment and other costs and $1.1 million of which relate to employee severance and related benefits.

In July 2022, the Company and its Board of Directors approved a strategic plan to align with its refocused pipeline on its next generation core inhibitors and research programs and reduced its workforce by approximately 30%. The Company expects to incur total restructuring charges of $1.1 million. Restructuring charges consist solely of employee severance and related benefits which include $1.0 million in severance payments to executive officers impacted by the restructuring, $0.8 million in one-time termination severance payments and other employee-related costs associated with the restructuring and a reversal of $0.7 million for previously recognized stock-based compensation

expense related to forfeited awards based on the Company's policy of recognizing stock-based awards with graded vesting schedules using an accelerated attribution method on a straight-line basis over the requisite service period for each separately vesting portion of the award and to recognize forfeitures when they occur.

The following table presents where the restructuring charges were recognized on the Company's consolidated statements of operations and comprehensive loss (in thousands):

	Year Ended December 31,	
	2022	2021
Research and development	$ 869	$ (1,625)
General and administrative	228	277
Total	$ 1,097	$ (1,348)

The following table presents the activity in accrued restructuring charges, included as a component of other accrued expenses on the Company's consolidated balance sheet, during the period (in thousands):

	Employee Severance and Related Benefits	Asset Impairment and Other Costs	Total Accrued Restructuring Charges
Accrued balance as of December 31, 2020	$ 4,164	$ —	$ 4,164
Costs incurred	—	1,611	1,611
Reductions for cash payments	(4,164)	(1,611)	(5,775)
Accrued balance as of December 31, 2021	$ —	$ —	$ —
Costs incurred	1,879	—	1,879
Reductions for cash payments	(1,280)	—	(1,280)
Accrued balance as of December 31, 2022	$ 599	$ —	$ 599

The Company expects the accrued restructuring charges to be fully paid by mid-2023.

Microbiome Purchase Agreement

In December 2021, the Company entered into an asset purchase agreement (the Microbiome Purchase Agreement) with a third party pursuant to which the Company sold know-how, patents, materials and regulatory filings for the Company's Microbiome program. The sale included ABI-M201 (M201), which had been the Company's lead candidate in its Microbiome program. As consideration for the sale, the Company was entitled to receive $3.0 million, of which $1.5 million was received in 2021 and the remaining $1.5 million was received in 2022. The Company is also entitled to receive a $10.0 million milestone payment upon the achievement of a regulatory approval milestone as defined in the purchase agreement.

The Microbiome Purchase Agreement is within the scope of gains and losses from the derecognition of nonfinancial assets guidance since the Company had previously wound-down the Microbiome program, M201 was no longer a part of the Company's ongoing major or central operations. The Company determined all assets sold under the Microbiome Purchase Agreement represent one distinct nonfinancial asset as individually, they do not have standalone value. The transaction price at the inception of the agreement was limited to the $3.0 million upfront payments. The variable consideration relating to the $10.0 million milestone has not been included in the transaction price as it was fully constrained as of December 31, 2022 and 2021. As part of the Company's evaluation of the development milestone constraint, it determined the achievement of the milestone is contingent upon success in future clinical studies and regulatory approvals which are not within its control and uncertain at this stage. The assets sold had no carrying value and the full $3.0 million transaction price resulted in the recognition of a gain upon the transfer of control of the assets sold in the year ended December 31, 2021. The $3.0 million gain is included as a reduction of research and development expenses in the Company's consolidated statements of operations and comprehensive loss for the year ended December 31, 2021. The $1.5 million due as of December 31, 2021 was included in prepaid expenses and other current assets on the Company's consolidated balance sheet.

Note 8 - Stockholders' Equity

The Company is authorized to issue 5,000,000 shares of preferred stock as of December 31, 2022 and 2021. As of December 31, 2022 and 2021, no shares of preferred stock were issued and outstanding. In May 2022, the Company's stockholders approved the Sixth Amended and Restated Certificate of Incorporation, which increased the authorized number of shares of common stock from 100,000,000 to 150,000,000.

Sale of Common Stock

In August 2020, the Company filed a shelf registration statement on Form S-3 with the SEC, File No. 333-248469, that became effective on September 4, 2020 (the 2020 Registration Statement). The Company may from time to time sell any combination of the securities described in the 2020 Registration Statement in one or more offerings up to an aggregate offering price of $300.0 million. In connection with the filing of the 2020 Registration Statement, the Company entered into a sales agreement under which the Company may offer and sell shares of its common stock having an aggregate offering price of up to $100.0 million through "at-the-market" offerings (2020 ATM), which shares are included in the $300.0 million of securities registered pursuant to the 2020 Registration Statement. During the year ended December 31, 2021, the Company issued and sold 11,234,207 shares of common stock under the 2020 ATM, for which the Company received net proceeds of $52.8 million, after deducting commissions, fees and expenses. During the year ended December 31, 2022, the Company issued and sold 300,827 shares of common stock under the 2020 ATM, for which the Company received net proceeds of $0.3 million, after deducting commissions, fees and expenses.

Common Stock Warrants

In December 2019, the Company sold to various investors an aggregate of 6,287,878 shares of common stock as well as pre-funded warrants to purchase 2,424,242 shares of common stock. The pre-funded warrants were immediately exercisable upon issuance at an exercise price of $0.001 per share and were recorded at the issuance date using a relative fair value allocation method as a component of permanent stockholders' equity within additional paid-in capital. During the year ended December 31, 2021, all 2,424,242 pre-funded warrants were exercised through a cashless exercise, resulting in the issuance of 2,423,634 shares of the Company's common stock.

Note 9 - Stock-Based Compensation

Equity Incentive Plans

In May 2021, the Company's stockholders approved an amendment to the 2018 Stock Incentive Plan (the 2018 Plan) that increased the aggregate number of shares of common stock reserved under the 2018 Plan to 6,600,000 and to the Assembly Biosciences, Inc. Employee Stock Purchase Plan (the 2018 ESPP) that, among other things, increased the number of shares of common stock reserved to an aggregate of 1,300,000.

In May 2022, the Company's stockholders approved an amendment to the 2018 Plan that increased the aggregate number of shares of common stock reserved under the 2018 Plan to 8,600,000.

As of December 31, 2022, the Company had awards outstanding under the following shareholder approved plans: 2010 Equity Incentive Plan (the 2010 Plan), which has been frozen; the Amended and Restated 2014 Stock Incentive Plan (the 2014 Plan); and the 2018 Plan. Shares of common stock underlying awards that are forfeited under the 2010 Plan on or after June 2, 2016 will become available for issuance under the 2014 Plan. As of December 31, 2022, the Company also had awards outstanding under the Assembly Biosciences, Inc. 2017 Inducement Award Plan, the 2019 Inducement Award Plan and the Assembly Biosciences, Inc. 2020 Inducement Award Plan.

The Company issues new shares of common stock to settle options exercised or vested RSUs. The Company also issues new shares of common stock in connection with purchases of shares of common stock by eligible employees under the Company's 2018 ESPP.

Stock Plan Activity

Stock Options

The following table summarizes the stock option activity and related information for 2022:

	Number of Shares	Weighted Average Exercise Price Per Share	Weighted Average Remaining Contractual Term (Years)	Total Intrinsic Value (in thousands)
Outstanding as of December 31, 2021	6,161,901	$ 11.77	6.4	$ 53
Granted	4,087,350	2.09		
Forfeited	(1,158,386)	14.43		
Outstanding as of December 31, 2022	9,090,865	$ 7.08	7.1	$ —
Options vested and exercisable as of December 31, 2022	4,262,287	$ 11.32	4.9	$ —

The weighted-average grant-date fair value of options granted was $1.48 and $3.05 during the years ended December 31, 2022 and 2021, respectively. There were no options exercised in 2022 or 2021.

RSUs

The following table summarizes RSU activity and related information for 2022:

	Number of RSUs	Weighted Average Fair Value Per RSU at Grant Price
Nonvested as of December 31, 2021	970,339	$ 7.04
Granted	1,255,275	2.06
Vested	(249,376)	8.88
Forfeited	(276,474)	5.26
Nonvested as of December 31, 2022	1,699,764	$ 3.39

The total fair value of RSUs vested and settled during 2022 and 2021 was $2.2 million and $3.7 million, respectively. The total intrinsic value of RSUs vested and settled during 2022 and 2021 was $0.5 million and $1.4 million, respectively.

In September 2019, the Company granted 100,000 RSUs with performance-based vesting conditions to its then-chief executive officer. In 2021, 50,000 of these awards were forfeited back to the Company due to the expiration of the time period to complete certain performance conditions. In 2022, the remaining 50,000 awards were forfeited back to the Company due to the expiration of the time period to complete the remaining performance conditions. No stock based compensation expense was ever recognized for these awards as achievement of the performance conditions was never deemed probable.

In July 2021, the Company granted a total of 324,214 RSUs with performance-based vesting conditions upon the achievement of clinical milestones to the majority of employees, including executive officers. The awards had a grant date fair value of $1.2 million and vest upon performance conditions which were deemed probable of being met as of December 31, 2022. Accordingly, the Company recognized a cumulative catch-up adjustment to stock-based compensation expense of $0.7 million for the year ended December 31, 2022. There was no stock-based compensation expense recognized for these RSUs during the year ended December 31, 2021.

In March 2022, the Company granted 255,000 RSUs with market-based vesting conditions to members of management, including its executive officers. The awards had a grant date fair value of $0.4 million and are being recognized over the derived service period of 1.5 years and vest upon the achievement of certain market-based conditions which have not been achieved as of December 31, 2022. The Company recognized stock-based compensation expense of $0.2 million for these RSUs for the year ended December 31, 2022.

In August 2022, the Company granted 525,000 RSUs with performance-based vesting conditions upon the achievement of clinical milestones to its executive officers. The awards had a grant date fair value of $1.1 million. Some of the performance conditions were deemed probable of being met as of December 31, 2022, and the Company recognized stock-based compensation expense of $0.1 million for these awards for the year ended December 31, 2022. No stock based-compensation expense was recognized for the awards with performance conditions not yet deemed probable of being met as of December 31, 2022.

Employee Stock Purchase Plan

The 2018 ESPP provides for the purchase by employees of up to an aggregate of 1,300,000 shares of the Company's common stock at a discount to the market price. Eligible employee may participate through payroll deductions of up to 15% of such employee's compensation for each pay period subject to annual statutory limits and the 2018 ESPP's limit, which the Company's stockholders approved in May 2021 to increase from 1,000 to 2,500 shares of common stock per offering.

Eligible employees can purchase the Company's common stock at the end of a predetermined offering period at 85% of the lower of the fair market value at the beginning or end of the offering period. Under the 2018 ESPP, the offering periods end on the last business day occurring on or before May 14 or November 14. The ESPP is compensatory and results in stock-based compensation expense.

In May and November 2021, employees purchased 42,803 and 46,017 shares of common stock, respectively, under the 2018 ESPP. In May and November 2022, employees purchased 134,888 and 90,944 shares of common stock, respectively, under the 2018 ESPP. As of December 31, 2022, 817,683 shares of common stock are available for future sale under the Company's 2018 ESPP. Stock-based compensation expense recorded in connection with the 2018 ESPP was $0.1 million for both the years ended December 31, 2022 and 2021.

Valuation Assumptions

The Company used the Black-Scholes option-pricing model for determining the estimated fair value and stock-based compensation related to stock options and ESPP purchase rights.

A summary of the assumptions used to estimate the fair values of stock options grants for the years presented is as follows:

	Year Ended December 31,	
	2022	2021
Exercise price	$1.53 - $2.45	$2.24 - $5.79
Expected volatility	78.49% - 81.72%	79.74% - 91.18%
Risk-free rate	1.41% - 4.15%	0.50% - 1.37%
Expected term (years)	5.5 - 7.5	5.5 - 7.5
Expected dividend yield	0%	0%

The risk-free interest rate assumption was based on the rates for U.S. Treasury zero-coupon bonds with maturities similar to those of the expected term of the stock option being valued. The expected dividend yield was zero as the Company currently does not intend to pay dividends in the foreseeable future. The weighted average expected term of options was calculated using the simplified method as prescribed by accounting guidance for stock-based compensation due to the Company's limited history of relevant stock option exercise activity. The expected volatility was calculated based on the Company's historical stock prices.

The fair value of ESPP purchase rights and stock appreciation rights were not material for any period presented.

Stock-Based Compensation Expense

The Company recognized stock-based compensation expense included in the consolidated statement of operations and comprehensive loss for the years presented (in thousands):

	Year Ended December 31,		
	2022	2021	
Research and development	$ 3,024	$ 548	(1)
General and administrative	3,569	4,689	
Total stock-based compensation expense	$ 6,593	$ 5,237	

(1) Includes the reversal of previously recognized stock-based compensation expense of $4.8 million related to forfeited awards of terminated employees, $2.7 million of which resulted from the wind-down of the Company's Microbiome program in January 2021.

As of December 31, 2022, there was $7.7 million of total unrecognized stock-based compensation related to outstanding equity awards which is expected to be recognized over a weighted average remaining amortization period of 1.6 years.

Note 10 - Collaboration Agreements

BeiGene Agreement

In July 2020, the Company and BeiGene, Ltd. (BeiGene) entered into a Collaboration Agreement (the BeiGene Agreement) to develop and commercialize the Company's novel core inhibitor product candidates vebicorvir (VBR), ABI-H2158 (2158) and ABI-H3733 (3733) for chronic HBV infection (the Licensed Product Candidates) in the People's Republic of China, Hong Kong, Taiwan and Macau (the Territory). Under the agreement, the Company and BeiGene are collaborating on certain global clinical studies and both the Company and BeiGene will independently conduct other clinical studies in their own respective territories.

BeiGene agreed to pay all development and regulatory costs for the Licensed Product Candidates in the Territory up to an aggregate of $45.0 million. Development and regulatory costs for the Licensed Product Candidates for the Territory in excess of $45.0 million will be shared equally by the Company and BeiGene. If the Company conducts certain ancillary trials outside of the plan to develop these candidates in the Territory, BeiGene may elect to obtain access to the know-how and clinical data resulting for such ancillary trials and shall reimburse the Company proportionally for the Territory of the costs of such trials. Activities under the BeiGene Agreement will be governed by a joint steering committee (JSC) consisting of equal representatives from each party to the agreement. All decisions of the JSC are to be made by consensus with final decision-making authority granted to each party based on key areas of the collaboration for which they are responsible. During the term of the BeiGene Agreement, neither party will commercialize any competing products in the Territory. The Company will be responsible for manufacturing and supply of the candidates to be used in and outside of the Territory, although the parties may approve BeiGene to take on some or all of the commercial supply activities of the applicable Licensed Products in the Territory.

The Company is not obligated to perform pre-phase 3 clinical trial development work outside the Territory but must provide BeiGene pre-Phase 3 clinical trial know-how and development results on the Licensed Product Candidates if and when such development efforts are completed. BeiGene may terminate the BeiGene Agreement for convenience at any time upon 90 days' advance written notice to Assembly. Such a termination would result in the Company regaining all rights to the Licensed Product Candidates in the Territory. The BeiGene Agreement also contains customary provisions for termination by either party, including in the event of breach of the BeiGene Agreement, subject to cure.

Pursuant to the terms of the BeiGene Agreement, the Company received an upfront cash payment of $40.0 million from BeiGene for the delivery of exclusive, royalty-bearing licenses to develop and commercialize the Licensed Product Candidates in the Territory, and the Company was eligible to receive up to approximately $500.0 million in cash milestone payments, comprised of up to $113.8 million for development and regulatory milestones and up to $385.0 million in net sales milestones. In addition, the Company is eligible to receive tiered royalties at percentages ranging from the mid-teens to the low thirties of net sales. In September 2021, the Company discontinued development

of 2158 following the observation of elevated alanine transaminase levels in the Phase 2 clinical study consistent with drug-induced hepatotoxicity, and in July 2022, the Company discontinued clinical development of VBR because it did not achieve functional cure or finite treatment in its two- and three-drug combination studies. Due to the discontinuation of development of VBR and 2158, the maximum cash milestone payments the Company is eligible to receive for 3733 is $285.0 million, comprised of up to $65.0 million for development and regulatory milestones and up to $220.0 million in net sales milestones.

The BeiGene Agreement is within the scope of the collaborative arrangements guidance as both parties are active participants and are exposed to significant risks and rewards dependent on the success of commercializing the Licensed Product Candidates in the Territory but that the unit of account related to the delivery of Licensed Product Candidates is within the scope of the contract with customers guidance. The remaining units of account related to participation on the JSC and subcommittees, clinical supply and other in Territory and global development activities (the Collaboration Activities) are within the scope of the collaborative arrangements guidance. Commercial supply will be evaluated as a separate contract when the agreement is executed and a purchase order is received from BeiGene.

The Company identified the following material promises related to the contract with customers unit of account under the BeiGene Agreement: 1) the transfer of the VBR License, 2) the transfer of the 2158 License, and 3) the transfer of the 3733 License. The Company concluded each of these licenses to be functional as they have significant standalone functionality and grants BeiGene the right to use the Company's intellectual property as it exists on the effective date of the license. The 2158 and 3733 Licenses have a continuing technology transfer obligation that is considered to be an attribute of these licenses. The agreed upon prices for the clinical and commercial supply of the Licensed Product Candidates to BeiGene do not represent material rights, and therefore are not performance obligations, and such pricing on an aggregate basis represents the SSP an entity would typically pay for such a product in that region or market. There are also no minimum purchase commitments.

The Company estimated the SSP of the licenses using an income-based valuation approach for the estimated value a licensor of the compounds would receive considering the stage of the compound's development. The Company believes a change in the assumptions used to determine its best estimate of SSP would not have a significant value or significant impact on the allocation of consideration received.

The transaction price at the inception of the agreement was limited to the $40.0 million upfront payment. The variable consideration related to the remaining development and commercialization milestone payments has not been included in the transaction price as these were fully constrained as of December 31, 2022 and 2021. As part of the Company's evaluation of the development and commercialization milestones constraint, the Company determined the achievement of such milestones are contingent upon success in future clinical trials and regulatory approvals which are not within its control and uncertain at this stage. Any variable consideration related to sales-based milestones (including royalties) will be recognized when the related sales occur as they were determined to relate predominantly to the Licensed Product Candidates granted to BeiGene. The Company will reevaluate the transaction price in each reporting period as uncertain events are resolved or other changes in circumstances occur.

Following the discontinuation of development of 2158 in September 2021, the obligation related to the technology transfer associated with the license of 2158 was considered to be complete. Accordingly, the Company recognized $6.3 million as collaboration revenue for the amount allocated to 2158 during the year ended December 31, 2021. No revenue was recognized during the year ended December 31, 2022. As of December 31, 2022 and 2021, the only remaining performance obligation under the BeiGene Agreement not considered to be complete is the transfer of the 3733 License. The transaction price allocated to 3733 of $2.7 million was recorded as a long-term deferred revenue contract liability on the consolidated balance sheet as of December 31, 2022 and 2021. Revenue for the remaining performance obligation will be recognized when the Company provides pre-Phase 3 clinical study know-how and development results for 3733 to BeiGene or a termination of the BeiGene Agreement for 3733.

Payments to, or reimbursements from, BeiGene related to the Collaboration Activities will be accounted for as an increase to or reduction of research and development expenses when incurred or realized, respectively. During the years ended December 31, 2022 and 2021, the Company did not recognize any increase or reduction of research and development expense under the BeiGene Agreement.

The Company incurred $3.5 million in incremental costs of obtaining the BeiGene Agreement. These contract costs have been capitalized and are being recognized consistent with the pattern of recognition of revenue associated with

the Licensed Product Candidates. As of both December 31, 2022 and 2021, the remaining unamortized contract costs are $0.2 million and are included in other assets on the consolidated balance sheet.

Arbutus Biopharma Agreement

In August 2020, the Company and Arbutus Biopharma Corporation (Arbutus Biopharma) entered into a Clinical Trial Collaboration Agreement (Arbutus Biopharma Agreement) to conduct a randomized, multi-center, open-label Phase 2 clinical trial to explore the safety, pharmacokinetics and antiviral activity of the triple combination of VBR, AB-729 and an NrtI compared to the double combinations of VBR with an NrtI and AB-729 with an NrtI. Under the Arbutus Biopharma Agreement, Assembly and Arbutus Biopharma share responsibility for the costs of the trial equally, excluding manufacturing supply which are the burden of each company to supply their respective drugs, VBR and AB-729. Assembly is responsible for conducting this clinical trial with Arbutus reimbursing Assembly its share of expenses.

The Arbutus Biopharma Agreement is within the scope of the collaborative arrangements guidance as both parties are active participants and are exposed to significant risks and rewards dependent on the success of the collaborative activity. Arbutus is not a customer as it does not obtain an output from the collaborative activities as they were not provided an exclusive license to VBR or the ability to manufacture VBR, and the Company does not consider performing such collaborative activities to be a part of its ongoing activities.

The revenue from contracts with customers guidance was considered by analogy in determining the unit of account, and the recognition and measurement of such unit of account for collaborative activities under the Arbutus Biopharma Agreement. The Company concluded there is one activity, to run an open-label Phase 2 clinical trial, which is akin to a performance obligation related to collaborative activities. Reimbursements and cost-sharing portions from Arbutus Biopharma are reflected as a reduction of research and development expense when realized in the Company's consolidated statements of operations, as the Company does not consider performing research and development services for reimbursement to be a part of its ongoing major or central operations. The Company recognized a reduction of research and development expense of $2.7 million and $2.0 million under the Arbutus Biopharma Agreement during the years ended December 31, 2022 and 2021, respectively. In February 2023, in consultation with Arbutus Biopharma, the companies decided to terminate the Phase 2 clinical trial early, at the end of the 48-week on-treatment period, and are in the process of closing the study.

Antios Agreement

In July 2021, the Company and Antios Therapeutics, Inc. (Antios) entered into a Clinical Trial Collaboration Agreement (the Antios Agreement) to collaborate on a triple combination therapy using VBR and Antios's active site polymerase inhibitor nucleotide ATI-2173 for the treatment of HBV. Assembly and Antios were individually responsible for the study's manufacturing costs but equally shared the remaining costs of the study. Antios was responsible for conducting the clinical trial with Assembly reimbursing Antios its share of expenses. In May 2022, the Company was notified by Antios that ATI-2173 had been placed on clinical hold by the U.S. Food and Drug Administration following submission of a safety report involving a patient who received a triple combination of VBR, ATI-2173 and a nucleos(t)ide analog reverse transcriptase inhibitor. Due to the clinical hold, the Company terminated the Antios Agreement effective May 2022.

During the year ended December 31, 2022, the Company incurred $0.4 million in research and development expenses under the Antios Agreement. There were no costs incurred during the year ended December 31, 2021.

Note 11 – Milestones and Research Agreements

HBV Research Agreement with Indiana University

Since September 2013, the Company has been party to an exclusive License Agreement dated September 3, 2013 with Indiana University Research and Technology Corporation (IURTC) from whom it has licensed aspects of the Company's HBV program held by IURTC. The license agreement requires the Company to make milestone payments based upon the successful accomplishment of clinical and regulatory milestones. The aggregate amount of all performance milestone payments under the IURTC license agreement, should all milestones through development be met, is $0.8 million, with a portion related to the first performance milestone having been paid. The Company is

obligated to pay IURTC royalty payments based on net sales of the licensed technology as well as a portion of any sublicensing revenue Assembly receives. The Company is also required to pay diligence maintenance fees each year to the extent that the royalty, sublicensing, and milestone payments to IURTC are less than such fees for that year. The Company paid IURTC $0.1 million in diligence maintenance fees during the year ended December 31, 2022 which are included in research and development expenses in the consolidated statements of operations and comprehensive loss. No amounts were paid during the year ended December 31, 2021.

Door Pharma Agreement

In November 2020, the Company and Door Pharmaceuticals, LLC (Door Pharma) entered into an exclusive, two-year Collaboration Agreement and Sublicense Agreement (collectively, the Door Pharma Agreement) focused on the development of a novel class of HBV inhibitors. The Company terminated the Door Pharma Agreement in May 2022, which became effective September 2022, to focus its resources on its other internal HBV programs and its programs targeting other viruses. Under the terms of the Door Pharma Agreement, the Company was obligated to continue to reimburse Door Pharma for certain research and development costs through September 2022 following which such reimbursements ceased.

Under the consolidation accounting standard, the Company determined that Door Pharma was a VIE. The Company did not have the power to direct the activities that most significantly affected the economic performance of Door Pharma and as such the Company was not the primary beneficiary and consolidation was not required prior to the termination of the agreement in May 2022.

During the years ended December 31, 2022 and 2021, the Company incurred research and development funding of $1.6 million and $1.8 million, respectively. Additionally, a performance milestone totaling $0.2 million was determined to have occurred under this agreement and was paid during the year ended December 31, 2021.

Note 12 - Income Taxes

Income tax benefit is as follows (in thousands):

	As of December 31,	
	2022	**2021**
Federal:		
Current	$ —	$ —
Deferred	—	1,160
Foreign	—	—
	—	1,160
State:		
Current	—	—
Deferred	—	1,371
Foreign	—	—
	—	1,371
Income tax benefit	$ —	$ 2,531

During the year ended December 31, 2021, the Company recognized a $2.5 million income tax benefit, with a corresponding reduction to the Company's valuation allowance, due to the reversal of the IPR&D deferred tax liability recorded in connection with the merger with Assembly Pharmaceuticals, Inc. in 2014. The impairment of the Company's IPR&D in 2021 resulted in the deferred tax liability related to this indefinite-lived intangible asset no longer being considered a source of income when assessing the realizability of the Company's deferred tax assets.

The effective tax rate of the Company's provision for income taxes differs from the federal statutory rate as follows:

	As of December 31,	
	2022	2021
Statutory federal income tax rate	21.0%	21.0%
State taxes, net of federal tax benefit	8.3	5.8
Research and development tax credits	3.3	2.3
Return to provision adjustments	—	(0.2)
Uncertain tax positions	(0.7)	(0.5)
Impairment of goodwill	—	(2.0)
Stock-based compensation	(2.9)	(4.5)
Other	(0.2)	(0.6)
Change in valuation allowance	(28.8)	(19.4)
Income taxes benefit	0.0%	1.9%

Significant components of the Company's deferred taxes are as follows (in thousands):

	As of December 31,	
	2022	2021
Deferred tax assets:		
Federal and state-operating loss carryforwards	$ 144,165	$ 133,671
Stock-based compensation	9,919	11,082
Capitalized research expense	15,004	—
Operating lease liabilities	880	1,656
Research and development credits	13,471	11,106
Other	1,372	1,125
Total deferred tax assets	184,811	158,640
Valuation allowance	(184,000)	(157,095)
Deferred tax asset, net of valuation allowance	$ 811	$ 1,545
Deferred tax liabilities:		
Operating lease right-of-use assets	$ (811)	$ (1,545)
Total deferred tax liabilities	(811)	(1,545)
Net deferred tax liability	$ —	$ —

The Company maintains a valuation allowance on deferred tax assets due to the uncertainty regarding the ability to utilize these deferred tax assets in the future. The valuation allowance increased by $26.9 million and $25.8 million for the years ended December 31, 2022 and 2021, respectively, primarily due to an increase in the Company's federal and state-operating loss carryforwards.

Net operating loss and tax credit carryforwards as of December 31, 2022 are as follows (in thousands):

	Amount	Expiration Years
Net operating losses, federal (post December 31, 2017)	$ 370,940	Indefinite
Net operating losses, federal (pre January 1, 2018)	123,552	2027 - 2037
Net operating loss, state (Indefinite)	880	Indefinite
Net operating loss, state (Definite)	625,852	2031 - 2041
Research and development tax credits, federal	12,952	2028 - 2041
Research and development tax credits, state	5,247	Indefinite

Pursuant to Internal Revenue Code (IRC), Section 382 and 383, use of the Company's U.S. federal and state net operating loss and research and development income tax credit carryforwards may be limited in the event of a cumulative change in ownership of more than 50.0% within a three-year period. The Company has performed an ownership change study through December 31, 2021 and has determined that a "change in ownership" as defined by IRC Section 382 and the rules and regulations promulgated thereunder, did occur in December 2010, January 2013 and October 2014. The Company has adjusted its net operating loss carryovers to appropriately reflect any attributes which will expire due to the limitation. The Company has not performed any additional analysis for IRC Sections 382 and 383 and there is a risk that additional changes in ownership could have occurred since December 31, 2021. If a change in ownership were to have occurred, additional net operating loss and tax credit carryforwards could be eliminated or restricted. If eliminated, the related asset would be removed from the deferred tax asset schedule with a corresponding reduction in the valuation allowance.

The following table summarizes activity related to the Company's gross unrecognized tax benefits (in thousands):

	As of December 31,	
	2022	2021
Balances as of beginning of year	$ 3,237	$ 2,655
Increases related to prior year tax positions	—	1
Decreases related to prior year tax positions	(36)	(82)
Increases related to current year tax positions	672	663
Balances as of end of year	$ 3,873	$ 3,237

The unrecognized tax benefits, if recognized, would not have an impact on the Company's effective tax rate assuming the Company continues to maintain a full valuation allowance position. Based on prior year's operations and experience, the Company does not expect a significant change to its unrecognized tax benefits over the next twelve months. The unrecognized tax benefits may increase or change during the next year for unexpected or unusual items for items that arise in the ordinary course of business. In subsequent periods, any interest and penalties related to uncertain tax positions will be recognized as a component of income tax expense.

The Company files income tax returns in the U.S. federal, California and other state and foreign jurisdictions and is not currently under examination by federal, state, or local taxing authorities for any open tax years. Due to net operating loss carryforwards, all years effectively remain open for income tax examination by tax authorities in the U.S. and states in which the Company files tax returns.

Note 13 - Leases

Operating Leases

The Company leases office and laboratory space in South San Francisco, California under a sub-sublease that expires in December 2023. The sub-sublease contains scheduled rent increases over the lease term. The Company also leases office space in Carmel, Indiana under a lease agreement that expires in August 2023. In February 2021, the Company subleased substantially all of the office space under lease in Carmel, Indiana for the remainder of its term. The Company also leased office and laboratory space in Groton, Connecticut that supported the Microbiome program under a lease that expired in June 2021. Due to the wind-down of the Microbiome program, the lease was not renewed. The Company's China subsidiary leased office space in Shanghai, which the Company let expire in March 2021. The Company also leased office space in Beijing under a lease agreement which the Company let expire in December 2021. The Company's China subsidiary leases registrational offices in Shanghai under a lease which expires in May 2023 and in Beijing which is month-to-month. Certain lease contracts contain renewal clauses that the Company assesses on a case-by-case basis. The Company also leases certain laboratory equipment accounted for as operating leases expiring at various dates, with the final lease expiring in 2025. In February 2021, the Company purchased substantially all of the leased equipment used for the Microbiome program from its leasing agency and sold this equipment to third parties.

When the Company cannot determine the implicit rate in its leasing arrangements, the Company uses its incremental borrowing rate as the discount rate when measuring operating lease liabilities. The incremental borrowing rate represents an estimate of the interest rate the Company would incur at lease commencement to borrow an amount equal to the lease payments on a collateralized basis over the term of a lease within a particular currency environment.

At December 31, 2022, the Company had operating lease liabilities of $3.5 million and ROU assets of $3.2 million.

The following summarizes quantitative information about the Company's operating leases (in thousands):

	Year Ended December 31,	
	2022	2021
Lease cost		
Operating lease cost	$ 3,505	$ 3,840
Short-term lease cost	23	268
Variable lease cost	1,573	1,317
Sublease income	(153)	(142)
Total lease cost, net	$ 4,948	$ 5,283

	Year Ended December 31,	
	2022	2021
Operating cash flows from operating leases	$ 3,670	$ 3,786
ROU assets exchanged for new operating lease liabilities	$ 171	$ 126

As of December 31, 2022, the weighted-average remaining lease term for operating leases was 1.0 years and the weighted-average discount rate for operating leases was 9.8%.

As of December 31, 2022, the maturities of the Company's operating lease liabilities were as follows (in thousands):

2023	$ 3,554
2024	73
2025	37
Total	3,664
Less: present value discount	(199)
Operating lease liabilities	$ 3,465

Note 14 - Employee Benefit Plan

In January 2018, the Company established a defined contribution 401(k) plan (the Plan) for all employees who are at least 21 years of age. Employees are eligible to participate in the Plan upon commencement of employment. Under the terms of the Plan, employees may make voluntary contributions as a percentage of compensation. The Plan also permits the Company to make discretionary matching contributions. During the years ended December 31, 2022 and 2021, the Company made discretionary matching contributions of $0.8 million and $0.9 million, respectively.

Note 15 - Subsequent Event

Subsequent to December 31, 2022, the Company sold 3,050,446 shares of common stock through its 2020 ATM resulting in net proceeds of $4.5 million.

The Company maintains its U.S. cash in deposit accounts with Silicon Valley Bank (SVB). On March 10, 2023, SVB was closed by the California Department of Financial Protection and Innovation, which appointed the Federal Deposit Insurance Corporation (FDIC) as receiver. On March 12, 2023, the U.S. Department of the Treasury, Federal Reserve and FDIC announced SVB depositors will have access to all of their money starting March 13, 2023 through a newly created, full-service FDIC-operated 'bridge bank' in an action designed to fully protect all depositors of SVB. Additionally, all of the Company's cash equivalents and marketable securities are held by a separate custodian bank. Accordingly, the Company does not anticipate the closure of SVB to have a material impact on its financial condition or operations.

Directors

William R. Ringo, Jr.
Former Chairman of the Board,
Five Prime Therapeutics, Inc.

Anthony E. Altig
Former Chief Financial Officer,
Biotix Holdings, Inc.

Gina Consylman
Former Chief Financial Officer,
Vedere Bio II, Inc.

Richard D. DiMarchi, Ph.D.
Distinguished Professor of Biochemistry
and Gill Chair in Biomolecular Sciences at
Indiana University

Sir Michael Houghton, Ph.D.
La Ka Shing Professor, Department of Medical
Microbiology at the University of Alberta

Lisa R. Johnson-Pratt, M.D.
Founder and Biotechnology, Cell and Gene
Therapy Commercial Advisor, Ananias Ventures

Susan Mahony, Ph.D.
Former Senior Vice President and President of
Lilly Oncology, Eli Lilly and Company

John G. McHutchison, A.O., M.D.
Former Chief Executive Officer and President,
Assembly Biosciences, Inc.

Jason A. Okazaki
Chief Executive Officer and President,
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Stock Listing

Assembly Biosciences, Inc. common stock is listed on The Nasdaq Global Select Market and quoted under the symbol "ASMB"

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