assembly bio

2020 Annual Report

Passionate about making a profound impact on patients' lives

Assembly Bio is an ambitious clinical stage biopharmaceutical company with cutting-edge therapeutic product candidates capable of improving the lives of millions living with chronic hepatitis B virus (HBV) infection around the world.

assemblybio

DEAR FELLOW STOCKHOLDERS,

2020 was one of the most uniquely difficult years in recent history as the world was — and continues to be — gripped by the COVID-19 global health crisis. We witnessed the commitment and perseverance of countless life science companies that, within just one year, launched thousands of clinical trials to evaluate treatment approaches and delivered three vaccines. I am proud to be among the biotech companies focused in virology and now even more impassioned to accomplish what Assembly Biosciences has always believed to be possible — freeing patients from the burden of lifelong treatment for chronic hepatitis B virus (HBV) infection.

> At Assembly Bio, 2020 was a year of significant progress and also one of learning.

We had hoped that our lead core inhibitor (CI) product, vebicorvir (VBR), in combination with standard-of-care nucleos(t)ide (Nrtl) therapy, would achieve an improvement in sustained virologic response (SVR) off-treatment versus Nrtl alone, given the safety and deeper viral suppression demonstrated in our Phase 2 studies. We also believed that if we could bring a cure to more than 270 million patients *today*, we owed it to them to explore that. Though the study did not achieve a favorable SVR result, we recognize that the insights from this trial further inform our work and the HBV field as a whole. More recently, we also updated our pipeline strategy to now focus solely on the pursuit of finite and curative therapies and forgo registrational studies aimed at improving current chronic suppressive therapy. This decision was made after internal and external discussions and analyses, including those with HBV experts, the FDA and, with respect to China, our partner BeiGene. Seeking to address the most significant unmet need for HBV patients — a finite treatment designed to cure — provides us the greatest potential to create value for the company's stockholders, while leveraging the expertise and passion of our management and entire organization.

With our focused strategy, the partnerships we established in 2020 and cash to fund operations into 2023, we are well positioned to continue advancing our portfolio of HBV core inhibitor clinical candidates and growing our pipeline of discovery programs toward this goal.

Our HBV Program: Where We Are Today

POTENT NEXT-GENERATION CORE INHIBITORS

- **ABI-H2158 (2158):** Phase 2 study is ongoing with interim data anticipated in the second half of 2021.
- **ABI-H3733 (3733):** Phase 1a study completed in healthy subjects.
- **Fourth Core Inhibitor Candidate:** New candidate on track to be nominated during the first half of 2021 with a potential best-in-class profile.

PROOF-OF-CONCEPT COMBINATION STUDIES WITH OTHER COMPLEMENTARY MECHANISMS

- **VBR + NrtI + interferon (peg-IFNα):** Phase 2a initiated.
- **VBR + NrtI + RNAi:** Phase 2 initiated.
- **Additional Combinations:** Further potential studies are under review to build upon the VBR + NrtI antiviral backbone by evaluating the addition of one or more complementary mechanisms of action.

RESEARCH PROGRAMS ON NEW TARGETS

- **Core Protein cccDNA Disruptors:** Complementary to our portfolio of core inhibitors.
- **Novel HBV Targets:** Initiation of two additional internal programs evaluating differentiated and undisclosed targets.

Updated Pipeline Strategy: Three Key Components to Drive Progress

Our HBV pipeline of core inhibitors is comprised of the most advanced and potentially best-in-class core inhibitors in development. We believe that core inhibitors administered with NrtI will form the backbone for finite and curative HBV combination therapies, and this approach is central to the three key components of our updated pipeline strategy:

- **Data-driven advancement of our core inhibitor candidates.** We have three core inhibitors in various stages of clinical development, VBR, ABI-H2128 and ABI-H3733, as well as a fourth discovery compound that we plan to nominate during the first half of 2021. With different chemical scaffolds, each candidate offers a unique profile and opportunity to more deeply suppress viral replication and prevent the formation of new cccDNA. The ultimate goal is to choose the best core inhibitors to move forward in future studies of finite and curative combinations.
- **Advancement of proof-of-concept multi-drug combination studies.** With a favorable safety profile and Phase 2 data already in hand, we are initially evaluating VBR combined with NrtI as the antiviral backbone in triple-combination studies with a third mechanism in treating patients with chronic HBV. We initiated two of these studies during the first quarter of 2021, one with Arbutus Biopharma's GalNAc delivered RNAi therapeutic candidate, AB-729, and the other with interferon.
- **Expansion of our discovery programs, both internally and externally.** During the

past year, we made significant strides in the expansion of our pipeline of research programs leveraging the strength of our research and development expertise in virology and HBV specifically. Through an external collaboration, we obtained the rights to a develop a novel class of HBV cccDNA disruptors targeting different phases of the HBV viral replication cycle distinct from and complementary to those targeted by our existing pipeline. In addition to the fourth CI compound, the team identified two additional novel targets, and we are focusing discovery efforts on generating compounds against them. We believe that our internal and external discovery programs and targets are differentiated in the space and have the potential to accelerate our progress toward the development of finite and curative therapies.

Continued Corporate and Scientific Momentum: 2020 in Retrospect

In 2020, we also accomplished a number of other important goals, including:

- Continuing to strengthen our leadership team and board of directors with the appointments of Chief Scientific Officer, Virology, William Delaney, PhD; Chief Legal and Business Officer, Jason Okazaki; Senior Vice President of Corporate Development, Carl Enell; Senior Vice President of Pharmaceutical Development and Manufacturing, Nicole White, PhD; and board member, Gina Consylman.
- Initiating a Phase 2 trial of our second-generation core inhibitor candidate, ABI-2158, for chronic HBV infection and later receiving FDA Fast Track Designation for its development and review.
- Forming new partnerships, including: a licensing and collaboration agreement with BeiGene for our three clinical-stage core inhibitors in the China Territory (including Taiwan, Macau and Hong Kong); a clinical collaboration agreement to evaluate VBR in combination with Arbutus Biopharma's AB-729 and Nrtl therapy; and a collaboration and option agreement with Door Pharmaceuticals for a novel class of cccDNA disruptors.
- Winding-down our microbiome program in the first quarter of 2021, focusing our strategy and resources on finite and curative therapies for HBV.

As I look back, I'm reminded of the tenacity and flexibility that our team showed while navigating 2020's personal and professional challenges. It's a privilege to work alongside our talented and experienced team that brings years of extensive HBV and virology experience to the company, as well as a track record executing in viral hepatitis.

With our refined strategy, strong resources, and focused discovery and development programs, I am excited for what the future brings along our path to developing finite and curative HBV therapies. We look forward to updating you as things progress.

Wishing you good health,

John McHutchison, AO, MD
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, 2020

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. ☒

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, 2020, was $756.9 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, 2020. 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, 2020. 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 February 22, 2021, there were 38,246,092 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 2021, to be filed within 120 days of the registrant's fiscal year ended December 31, 2020.

ASSEMBLY BIOSCIENCES, INC.
TABLE OF CONTENTS

References to Assembly Biosciences, Inc.

Throughout this Annual Report on Form 10-K, the "Company," "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" 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. The forward-looking statements in this Annual Report on Form 10-K include, among other things, statements about:

- our ability to initiate and complete clinical trials involving our chronic hepatitis B virus (HBV) therapeutic product candidates in the currently anticipated timeframes;
- safety and efficacy data from clinical 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;
- continued development and commercialization of our HBV product candidates will be dependent on, and subject to, our collaboration agreement governing our activity in the China territory;
- our ability to maintain financial resources necessary to continue our clinical studies and fund business operations; and
- any impact that the COVID-19 pandemic may have on our business and operations, including initiation and continuation of our clinical studies or timing of discussions with regulatory authorities.

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. 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 clinical-stage biotechnology company advancing a novel class of oral therapeutic candidates for the treatment of chronic hepatitis B virus (HBV) infection. According to the World Health Organization (WHO), approximately 270 million people worldwide are chronically infected with HBV. Our research and development programs are pursuing multiple drug candidates designed to inhibit the HBV replication cycle and block the generation of covalently closed circular DNA (cccDNA), with the aim of discovering and developing finite and curative therapies for patients with HBV. We have discovered several novel core inhibitors, which are small molecules that directly target and allosterically modulate the HBV core (HBc) protein in a way that affects assembly and stability of HBV nucleocapsids.

The ongoing COVID-19 pandemic has affected certain aspects of our business. As further detailed below, those effects have been primarily limited to where and how our employees work in our labs and offices. To date, our current and future planned clinical trials and pre-clinical studies have not been subject to significant impact as a result of the COVID-19 pandemic.

As previously announced, in January 2021, we wound down our Microbiome program to prioritize and focus our resources on discovering and developing finite and curative therapies for HBV. Our Microbiome program had been developing a novel class of oral live microbial biotherapeutics candidates designed to treat disorders associated with the microbiome.

HBV Background

HBV is a leading global cause of chronic liver disease and liver transplants. The WHO estimates that approximately 270 million people worldwide are infected with HBV and 887,000 people died in 2015 as a result of HBV, mostly from complications, including cirrhosis and hepatocellular carcinoma. HBV is a global epidemic and infects more than twice the number of people infected with hepatitis C virus and HIV infections combined, according to the WHO as of the end of 2019. Of the approximately 270 million people living with HBV infection, only approximately 30 million were aware of their infection, and only approximately 5 million of those diagnosed received treatment. Few treated patients exhibit cure, defined herein as sustained viral suppression (more than six months) of HBV DNA (less than the lower limit of quantification (LLOQ)) after a finite duration of therapy.

Current Treatments

There have been no new mechanisms used to treat chronic HBV approved in 25 years. Current therapeutic options for HBV include:

- **Direct Acting Antiviral medications (Nucelos(t)ide analog reverse transcriptase inhibitors (NrtIs)).** Several antiviral medications—including lamivudine (Epivir®), adefovir (Hepsera®), telbivudine (Tyzeka®), tenofovir alafenamide (Vemlidy®), tenofovir disoproxil fumarate (Viread®) and entecavir (Baraclude®)—effectively reduce circulating virus levels by inhibiting reverse transcription. Chronic therapy with these agents can result in reduced liver inflammation and fibrosis. Unfortunately, these are rarely curative, even after years of therapy, and viral replication resumes when therapy is stopped.

- **Pegylated Interferon alfa (Peg-IFNα or interferon).** This synthetic version of a substance produced by the body to fight infection is used mainly for people infected with HBV who do not want to undergo long-term treatment (e.g., patients who might want to become pregnant within a few years). It is administered by injection. Cure rates are relatively low and side effects may be severe, including flu-like symptoms and depression.

Business Strategy

Our goal is to discover and develop finite and curative therapies for those chronically infected with HBV. Our efforts to forge a new and differentiated path to develop finite and curative therapies for chronic HBV infection are inspired by the millions living with this condition worldwide. While we have learned that combination therapy of our first-generation core inhibitor product candidate, vebicorvir (VBR), with NrtIs alone will not result in a finite and curative treatment, we believe that a regimen of core inhibitors in combination with NrtI therapy will be the antiviral backbone of future finite and curative therapies. As a result, our business strategy is focused on three parallel paths:

- Developing and advancing VBR, ABI-H2158 (2158) and ABI-H3733 (3733), our current clinical-stage core inhibitor product candidates, and identifying and selecting a fourth-generation core inhibitor product candidate with a profile superior to 2158 and 3733;

- Assessing core inhibitors in multi-drug combination studies, adding non-overlapping mechanisms of action to the core inhibitor + NrtI backbone; and

- Discovering and developing additional compounds beyond core inhibitors, including a cccDNA disruptor and a number of other recently initiated novel pre-clinical programs.

With respect to our core inhibitor pipeline, we have concise, data-driven development plans to enable selection of the optimal core inhibitor to advance for finite and curative combination therapies for HBV. We intend to complement our core inhibitor programs with additional new mechanisms of action discovered and developed internally as well as externally through collaborations, licenses, partnerships and other types of business arrangements.

Our Primary Focus: Targeting HBV Core Protein to Achieve a Cure

HBV is a DNA virus that infects hepatocytes and establishes a reservoir of cccDNA, a unique 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, most of our research and development efforts to date have focused on discovering and developing compounds targeting the core protein, a highly conserved viral structural protein that has no human homologue and is 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 core inhibitors that directly target and allosterically inhibit core protein functions. Our pipeline therefore 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. We believe that our approach of targeting viral core protein and its related functions provides a promising foundation for finite and curative HBV treatment regimens.

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 core inhibitors have shown preclinical proof of principle. In a variety of cell culture models, core inhibitors 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).

In pursuit of our goal of developing finite and curative therapies for patients with chronic HBV infection, we plan on advancing the optimal core inhibitor in our portfolio for use as an anti-viral backbone with NrtI. While we have three candidates in clinical studies and are working towards identifying a fourth-generation candidate later this year, we will follow a disciplined, data-driven approach to identify the optimal candidate(s) to produce potentially higher cure rates than are currently obtainable for patients with chronic HBV infection under the current standard of care.

Our Core Inhibitor Product Candidates

Our clinical strategy encompasses testing core inhibitors first as a monotherapy in Phase 1, as required by regulatory agencies, to demonstrate their intrinsic antiviral activity and safety and subsequently in Phase 2 in combination with NrtI and potentially other classes of HBV therapies.

Vebicorvir

VBR, our lead core inhibitor product candidate, is licensed from Indiana University. The conduct of the Phase 2 studies, Study 201 and 202 and our open-label extension study, Study 211, are all complete. We presented interim updates on our clinical studies at a variety of conferences, including at the European Association for the Study of the Liver's (EASL) Digital International Liver Congress™ in August 2020 and the American Association for the Study of Liver Diseases (AASLD) Annual Meeting in November 2020.

Our most recently completed study for VBR, Study 211, involved transitioning patients who met the requisite stopping criteria, as determined with our lead investigators and the U.S. Food and Drug Administration (FDA), off of therapy to test for sustained virologic response (SVR). SVR refers to sustained viral suppression (more than six months) of HBV DNA below LLOQ and would be consistent with a successful finite treatment for HBV. In November 2020, it became clear that patients who stopped therapy in Study 211 had not achieved meaningful SVR rates as 39 of 41 patients relapsed, meaning they had detectable HBV. We continue to analyze Study 211 data and intend to submit more detailed findings to a future medical meeting; however, it is clear that combination therapy of VBR plus NrtI alone is not sufficient to cure HBV. Based on these results, we terminated Study 211 prior to its completion.

Despite the off-treatment results in Study 211, the Phase 2 studies demonstrated on-treatment that subjects receiving VBR plus NrtI achieved faster and deeper suppression of viral replication compared to placebo. Based on this data, we believed that the addition of VBR to NrtI therapy could potentially help two patient populations as a chronic suppressive treatment (CST): (1) treatment-naïve patients, for whom addition of VBR to NrtI could lead to faster and deeper viral suppression and (2) partially virologically suppressed patients who continue to have viral levels above LLOQ by commercial assays, for whom the addition of VBR to NrtI could suppress viral levels below what could be achieved by NrtI alone.

In connection with preparation for registrational studies for VBR in CST in 2020, we held a number of discussions with leading viral hepatitis experts regarding use of VBR as a CST. In addition, we initiated an additional Phase 2 study of VBR, Study 205, to evaluate treatment intensification with VBR in patients with chronic HBV infection who are only partially virologically suppressed on NrtI.

In the second half of 2020, we also held an End-of-Phase 2 meeting with the National Medical Products Administration, Center for Drug Evaluation, China, and reached agreement on a Phase 3 registrational program for CST use of VBR plus NrtI. We also had discussions with the FDA regarding the same Phase 3 registrational program.

Based on discussions with leading viral hepatitis experts, global regulatory discussions and feedback, and, with respect to the China territory, discussions and agreement with our collaboration partner, BeiGene, Ltd. (BeiGene), we recently decided to not move forward with the global registrational studies for VBR as a chronic suppressive treatment (CST) with NrtI. The decision was made to focus on the greatest unmet medical need of patients, which lies predominantly in cure, rather than CST. As a result, we also expect to terminate Study 205, as we focus our efforts with VBR moving forward in combination with NrtI and additional mechanisms targeting finite and curative combination therapy.

ABI-H2158

Our second-generation core inhibitor product candidate, 2158, was internally discovered and developed and is chemically distinct from VBR.

We reported the final data from dose-ranging cohorts of the Phase 1b portion of the Phase 1a/1b dose-ranging clinical study at EASL in August 2020. Based on data from the Phase 1b dose-ranging study, we initiated a Phase 2 clinical study in June 2020 using a 300 mg daily dose of 2158. This study is being conducted in approximately ten countries in Asia, North America and Europe. We expect interim data from this study in the second half of 2021. While we will continue to monitor the situation closely, at this time, we do not expect our timelines for this study to be significantly impacted by the COVID-19 pandemic.

ABI-H3733

Our third core inhibitor product candidate, 3733, has completed Investigational New Drug (IND) enabling studies. 3733 has a novel chemical scaffold separate from both VBR and 2158. We presented a preclinical profile of this candidate in the first quarter of 2019.

In the first quarter of 2020, we initiated a Phase 1a clinical study to evaluate safety, tolerability and pharmacokinetics (PK) following single ascending dose and multiple ascending dose administration of 3733 in healthy subjects in New Zealand. Conduct for the study was completed in the fourth quarter of 2020 and preliminary data indicate that 3733 was generally well-tolerated and had favorable PK.

Additional Product Candidates

In addition to our three clinical-stage product candidates, our research discovery team is actively focused on identifying and selecting a fourth-generation core inhibitor candidate, which we anticipate in the first half of 2021.

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 related to the first performance milestone 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 are 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 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.

If, after 2158 and 3733 reach 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, as applicable. 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.

Multi-Drug Combination Studies

We believe that core inhibitors and NrtI will be central to finite and curative therapies for chronic HBV infection. Therefore, as we continue to develop and advance our current and future core inhibitors through clinical studies, we plan to conduct multi-drug combination studies in parallel that add additional drugs (or compounds) with non-overlapping mechanisms of action to the core inhibitor + NrtI antiviral backbone. Specifically, we plan on only incorporating our current and future core inhibitors that have demonstrated they are well-tolerated and effective in clinical studies in dual combination with NrtI. As the 300 mg daily dose of VBR has been observed to be well-tolerated in all studies conducted to date, with no serious adverse effects or dose-limiting toxicities identified and no pattern of treatment-emergent clinical or laboratory abnormalities observed and has progressed beyond dual combination studies, we currently have two triple combination studies planned to study VBR in combination with NrtI and a third mechanism of action.

In August 2020, we entered into a Clinical Trial Agreement with Arbutus Biopharma Corporation (Arbutus), pursuant to which we and Arbutus will conduct a randomized, multi-center, open-label Phase 2 clinical trial to explore the safety, PK and antiviral activity of the triple combination of VBR, NrtI and AB-729 compared to the double combinations of VBR plus NrtI and AB-729 plus NrtI in virologically suppressed patients. This clinical study is projected to initiate in the first half of 2021.

Our second triple combination study evaluates VBR and NrtI in combination with interferon in treatment-naïve HBeAg positive subjects and was initiated in the first quarter of 2021.

In addition to the above studies, we expect to continue to pursue additional multi-drug combinations that include other or additional non-overlapping mechanisms of action to the core inhibitor + NrtI antiviral backbone.

Beyond Core Inhibitors

In addition to the development and advancement of our core inhibitor portfolio and our current and future multi-drug combination studies, our research and development team is working on discovering and developing a potent fourth-generation core inhibitor, cccDNA disruptors and small molecules targeting novel undisclosed targets to add to the core inhibitor + NrtI antiviral backbone to achieve cure. In November 2020, we entered into an exclusive, two-year collaboration and option agreement with Door Pharmaceuticals (Door Pharma) focused on the development of a novel class of HBV inhibitors. Door Pharma's discovery platform targets functions of core protein distinct from viral assembly and have the potential to interfere with viral nucleic acid including intra-nuclear cccDNA, providing a strong complement to our current portfolio. Together with Door Pharma, we are working on identifying cccDNA disruptors, which will be aimed at inhibiting different intra-nuclear steps in the viral replication cycle that complement the activity of our core inhibitors.

Under the terms of the agreement, Door Pharma will build upon its previous efforts to lead and conduct new discovery research, which we will fund. In return for an up-front payment and success-based milestones and royalties, we will be granted an exclusive option to license compounds arising from the collaboration and will be responsible for the continued development and commercialization of optioned compounds.

Intellectual Property

In regard to our HBV patent estate, we co-own with and exclusively license from Indiana University two issued U.S. patents and related foreign patents and patent applications that relate to compositions of matter and methods of using VBR. The issued U.S. patents are expected to expire in 2035 and 2036. In addition, we own a pending U.S. patent application and related foreign applications directed to a process for preparing VBR; any patents issuing therefrom are expected to expire in 2038. Finally, we own an international (PCT) patent application directed to formulations of VBR; any patents issuing therefrom are expected to expire in 2040.

We own a pending U.S. patent application and related foreign applications that relate to compositions of matter and methods of using 2158; any patents issuing therefrom are expected to expire in 2038.

We own a PCT patent application that relates to compositions of matter and methods of using 3733; any patents issuing therefrom are expected to expire in 2039.

Microbiome Program

Following the termination of the Research, Development, Collaboration and License Agreement between the Company and Allergan Pharmaceuticals International Limited, which was acquired by AbbVie, Inc. in May 2020, we began an extensive process to identify strategic alternatives to continue the development of the Microbiome program upon the return of the related intellectual property rights. This process did not result in us receiving any bids on any portion of the Microbiome program, including our facility in Groton, Connecticut.

As a result, in December 2020, we and our Board of Directors (the Board) decided to wind down our Microbiome program as of January 31, 2021, including our facility in Groton, Connecticut, to prioritize and focus our resources on our HBV programs.

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 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.

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 $2.9 million and the sponsor of an approved NDA is also subject to an annual program fee currently set at $0.3 million through September 30, 2021. 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.

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 and 2020, the FDA granted fast track designation to VBR and 2158, respectively, 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. A fast track designated product candidate would ordinarily meet the FDA's criteria for priority review.

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.

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.

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 and marketing 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.

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.

In order to secure coverage and reimbursement for any product that might be approved for sale, we may need to conduct expensive pharmacoeconomic studies in order to demonstrate the medical necessity and cost-effectiveness of the product, in addition to the trials required to obtain FDA or other comparable regulatory approvals. Our product candidates may not be considered medically necessary or cost-effective. A payor's decision to provide coverage for a drug product does not imply that an adequate reimbursement rate will be approved. Companies may also need to provide discounts to purchasers, private health plans or government healthcare programs. Third-party reimbursement 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 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.

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. 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 allow us to sell our products at a profit. The U.S. government, state legislatures and foreign governments have shown significant interest in implementing cost containment programs to limit the growth of government-paid health care costs, including price controls, restrictions on reimbursement and requirements for substitution of generic products for branded prescription drugs. Adoption of such controls and measures and tightening of restrictive policies in jurisdictions with existing controls and measures, could limit payments for pharmaceuticals such as the drug candidates that we are developing and could adversely affect our net revenue and results. Even if favorable coverage and reimbursement status is attained for one or more products for which we may receive regulatory approval, less favorable coverage policies and reimbursement rates may be implemented in the future.

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. In particular, in the United States, the Affordable Care Act (ACA) and its amendment, the Health Care and Education Reconciliation Act, contains provisions that may reduce the profitability of drug

products, including, for example, increased rebates for drugs sold to Medicaid programs, extension of Medicaid rebates to Medicaid managed care plans, mandatory discounts for certain Medicare Part D beneficiaries and annual fees based on pharmaceutical companies' share of sales to federal health care programs.

Among the provisions of the ACA of importance to our potential drug candidates are the following:

- an annual, nondeductible fee on any entity that manufactures or imports specified branded prescription drugs;
- an increase in the statutory minimum rebates a manufacturer must pay under the Medicaid Drug Rebate Program;
- expansion of healthcare fraud and abuse laws, including the False Claims Act and the Anti-Kickback Statute, new government investigative powers, and enhanced penalties for noncompliance;
- a new Medicare Part D coverage gap discount program, in which manufacturers must agree to offer 70% point-of-sale discounts off negotiated prices of applicable brand drugs under the Bipartisan Budget Act of 2018 (BBA);
- extension of manufacturers' Medicaid rebate liability;
- expansion of eligibility criteria for Medicaid programs;
- expansion of the entities eligible for discounts under the Public Health Service Act pharmaceutical pricing program;
- requirements to report financial arrangements with physicians and teaching hospitals;
- a requirement to annually report drug samples that manufacturers and distributors provide to physicians; and
- a Patient-Centered Outcomes Research Institute to oversee, identify priorities in, and conduct comparative clinical effectiveness research, along with funding for such research.

Since its enactment, there have been many judicial, Presidential, and Congressional challenges to numerous aspects of the ACA. For example, former President Trump issued several executive orders and other directives designed to delay, circumvent, or loosen certain requirements or implementation of certain requirements mandated by the ACA. Concurrently, 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, signed into law in 2017, effectively repealed the individual health insurance mandate, which is considered a key component of the ACA, and the U.S. Supreme Court recently heard oral arguments regarding the constitutionality of the ACA and the individual mandate, with a decision expected during the current term in 2021. 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. Moreover, the BBA, among other things, amended the ACA to close the coverage gap in most Medicare drug plans, commonly referred to as the "donut hole".

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 2030, with the exception of a temporary suspension from May 1, 2020 through March 2021, unless additional Congressional action is taken. 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.

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, at the federal level, the Trump Administration issued several executive orders related to prescription drug pricing and sent "principles" for drug pricing to Congress. 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. In November 2020, the Trump Administration and the U.S. Department of Health and Human Services (HHS) announced regulations tying certain Medicare Part B drug prices to international drug prices, modifying certain federal Anti-Kickback Statute (AKS) safe harbors, including removing safe harbor protection for rebates negotiated between drug manufacturers and pharmacy benefit managers (PBMs) or health plan sponsors in Medicare Part D, and making further changes to the rules implementing the Stark Law, other AKS safe harbors and the beneficiary inducements provision in the civil monetary penalties law. On November 20, 2020, CMS issued an interim final rule implementing President Trump's Most Favored Nation executive order, which would tie Medicare Part B payments for certain physician-administered drugs to the lowest price paid in other economically advanced countries. However, on December 28, 2020, the United States District Court in Northern California issued a nationwide preliminary injunction against implementation of the interim final rule, and CMS announced that the Most Favored Nation Model will not be implemented without further rulemaking. There also have been legal challenges to the modified AKS safe harbor for drug rebates, which delayed implementation of the modified safe harbor until January 1, 2023, pending HHS's review, and gave the Biden Administration until April 1, 2021 to decide whether to defend the rebate rule in court. The Biden Administration also has issued a final rule to delay the effective date of other provisions of the rebate rule that were scheduled to take effect on January 29, 2021 to March 22, 2021. The likelihood of implementation of any of the other Trump Administration reform initiatives is uncertain, particularly in light of the change in presidential administrations. Individual states in the United States have also become increasingly active in passing legislation and implementing regulations designed to control pharmaceutical and biological product pricing, including price or patient reimbursement constraints, discounts, restrictions on certain product access and marketing cost disclosure and transparency measures. Accordingly, the ultimate content, timing or effect of healthcare reform legislation on the United States healthcare industry is unclear.

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 recently 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. The CCPA went into effect on January 1, 2020, and the California Attorney General began taking enforcement action against violators beginning July 1, 2020. 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.

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, Vir Bio and Aligos Therapeutics, 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 VBR, 2158 and 3733 used in our clinical and nonclinical studies. We currently have no plans to establish any manufacturing facilities for our product candidates.

Human Capital Management

Employees

As of December 31, 2020, we had 139 total employees and contracts with a number of temporary contractors, consultants and contract research organizations. Our employees are spread across facilities in South San Francisco, California, Groton, Connecticut and a small facility in China. We also have a small number of remote employees spread across the United States. During 2020, we increased our headcount by adding 51 new employees. The new employees were hired to support, extend and grow our clinical and preclinical pipeline, with new hires in clinical development and operations, research, manufacturing and general and administrative functions, including expanding our corporate development team. Following the wind-down of our Microbiome program on January 31, 2021, we had 95 total employees, with one employee remaining in Groton, Connecticut to manage the shutdown of that facility.

While we wound down our Microbiome program in early 2021, we expect to continue to add employees to support our HBV programs in 2021, with a focus on continuing to build out our clinical team to support ongoing and planned clinical development studies and building out our preclinical research and development team under our new Chief Scientific Officer, who joined us in May 2020. We continually evaluate our needs and make strategic choices regarding whether to hire internal teams or outsource certain functions to contract research organizations (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. 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; 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.

COVID-19 Response

Shortly after the counties in the San Francisco Bay Area implemented a shelter-in-place order, followed quickly by California's similar statewide order, we established a COVID-19 Task Force (the Task Force) that has held regular meetings since it was established. The Task Force, in conjunction with our Human Resources department, has taken the following actions in our effort to curb the pandemic:

- Drafting and distributing comprehensive COVID-19 office and exposure policies, and lab and safety protocols, each of which have been modified as federal, state and local governments have updated their guidance;
- Requiring all employees who are able to do so to work remotely;
- Holding Company-wide virtual Town Hall meetings at least monthly to foster a sense of community given that the majority of our employees worked remotely;
- Increasing cleaning protocols at U.S. office and lab facilities;
- Providing all employees with cloth face coverings and increasing availability of personal protective equipment to lab employees;
- Prohibiting all work-related domestic and international travel; and
- Requiring masks to be worn at all Company locations.

The Task Force will continue to hold regular meetings to discuss and update internal guidance and protocols until we determine that meetings are no longer necessary.

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) 409-4583.

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 shareholders 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 Securities and Exchange Commission. 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 our HBV program. 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 product candidates 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.

The COVID-19 pandemic may materially and adversely affect our business.

The continued spread of COVID-19 could adversely impact our research and development through delay, modification or suspension of our clinical and/or nonclinical studies. Other clinical-stage biotechnology companies, like us, have had their clinical and nonclinical studies affected by the COVID-19 pandemic.

The COVID-19 pandemic has and may continue to: (1) impact patient enrollment, retention or compliance with clinical study protocols; (2) require modifications to, or deviations from, study protocols and procedures, such as the use of telehealth and home health visits instead of on-site monitoring and treatment, which could increase the cost of, and time for, conducting clinical studies; (3) disrupt or suspend the business operations of our third-party contract research organizations (CROs), manufacturers of our drug candidates and the clinical sites conducting our clinical studies; (4) delay regulatory meetings and filings with regulatory agencies in the United States and other countries; and (5) disrupt supply chains and cause delays of shipments of critical reagents, PPE and disinfectants, each of which are necessary for our laboratories and the laboratories of our CROs to maintain normal workflows. Even if we are able to timely collect clinical data while the outbreak is ongoing, COVID-19 may negatively affect the quality, completeness, integrity, interpretability and cost of obtaining such clinical study data.

The full extent of the pandemic's impact on our business will depend on future developments, which are highly uncertain and cannot be predicted with confidence, such as the duration and severity of the pandemic and the effectiveness of actions for containment, treatment and prevention of COVID-19. However, any COVID-19-related business interruptions or delays could materially and adversely affect our ability to conduct our research and development activities in the manner and on the timelines presently planned as well as negatively affect the accuracy of our estimates regarding capital requirements, needs for additional financing and our ability to produce accurate and timely financial statements. Any of these disruptions could have a material adverse impact on our business, results of operations, financial condition and share price.

As a result of the COVID-19 pandemic, governments around the world implemented significant measures to control the spread of the virus, including quarantines, travel restrictions, stay-at-home orders and business shutdowns. While governments have relaxed these measures as cases numbers go down, periodic surges in COVID-19 cases have, and may in the future, prompted many governments to reimplement these restrictions, including in Europe and the United States. We continue to take precautionary measures intended to minimize our employees' potential exposure to the virus, including temporarily requiring all employees who are able to do so to work remotely and suspending all non-essential business travel worldwide for our employees. Requiring all employees to work remotely may disrupt our operations, increase the risk of a cybersecurity incident or otherwise negatively affect our business.

In addition to the risks related to the COVID-19 pandemic discussed above, the uncertainty surrounding, and risks created by, the pandemic may have the effect of heightening many of the other risks discussed in this section impacting our operations.

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 or debt financings and payments we may receive from out-licensing, collaborations or other strategic arrangements. However, 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. 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 testing required for our product candidates is 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 in humans. To meet these requirements, we must conduct extensive nonclinical testing and sufficient, well-controlled clinical studies.

The results of nonclinical studies may not be representative of disease behavior in a clinical setting and thus 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 trial 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 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 trial 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 this testing due to our lack of suitable facilities and resources.

We do not have sufficient facilities or resources to conduct all of our anticipated nonclinical and clinical testing internally. As a result, we contract with CROs to conduct a significant portion of the nonclinical and clinical testing 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 not be able to complete our clinical studies and may fail to obtain regulatory approval for our product candidates.

Furthermore, 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 programs. If the 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 studies 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.

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

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 or trial. 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 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 VBR, 2158 and 3733 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 compounds, drug substances and drug products for nonclinical, clinical and commercial purposes. We may not be successful 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 not be able 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 in order 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, thereby risking the 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 loss of any of these key employees could have a material adverse impact on our business, financial condition and results of operations.

Fast Track designations for VBR and 2158 may not result in faster development, regulatory review or approval.

If nonclinical or clinical data demonstrate potential to address unmet medical needs for a serious or life-threatening condition, the sponsor may apply for FDA Fast Track designation. Fast Track designation provides increased opportunities for sponsor meetings with the FDA during nonclinical and clinical development, in addition to the potential for rolling review once a marketing application is filed. Both VBR and 2158 have received Fast Track designation for the treatment of patients with chronic HBV infection. However, even with Fast Track designation, we may not experience a faster development process, review or approval compared to conventional FDA procedures. Fast Track designation does not assure ultimate approval by the FDA. The FDA may withdraw Fast Track designation if it believes that the designation is no longer supported by data from our product development program. Any such withdrawal could adversely affect our business.

We are dependent on an in-license relationship for VBR.

Our license agreement with IURTC imposes diligence requirements on us and requires us to make milestone payments based upon the successful accomplishment of clinical and regulatory milestones related to VBR, royalty payments if VBR is approved and diligence maintenance fees. These payments will make it less profitable for us to develop VBR than if we owned the technology outright. In addition, if we breach any of our obligations under our license agreement, IURTC may have a right to terminate the license, in which event we could lose our rights to VBR.

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 (HITECH), and its implementing rules and regulations, as well as regulations promulgated by the Federal Trade Commission, state breach notification law and the European Union's General Data Protection Regulation (GDPR). 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 landscape for HBV is 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 or any other indication or field we might pursue, and successfully commercialize those treatments, our business and prospects could be materially harmed.

Companies with core inhibitor products 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.

Our HBV therapy research and development efforts involve therapeutics based on modulating forms of HBV core proteins with core inhibitors. Negative data from clinical studies using a competitor's core inhibitors 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 core inhibitors, 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 core inhibitor 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 core inhibitor therapies, 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 are able to 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 the applicable regulatory authorities in foreign jurisdictions to commercialize our product candidates in those jurisdictions. In order 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 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 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.

California recently enacted the 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 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 trial regulations, as currently written, the CCPA may impact our business activities. The uncertainty surrounding the implementation of 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 contract research organizations 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 United States Foreign Corrupt Practices Act (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 in the course of 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 be in compliance 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.

We have international operations, including in China, and conduct clinical studies outside of the United States. A number of risks associated with international operations could materially and adversely affect our business.

We expect to be subject to a number of risks related with our international operations, many of which may be beyond our control. These risks include:

- 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 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;
- 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; and
- business interruptions resulting from geopolitical actions, including tariffs, war and terrorism, natural disasters or outbreaks of disease.

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 not be able to file and prosecute all necessary or desirable patent applications at a reasonable cost or in a timely manner. It is also possible that we will 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 (API) 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 (the 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. Thus, even if we or our licensors are able to 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 in order 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, as a result 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 recently 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 not be able 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 (the Court of Chancery) 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 studies 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. Prior to moving into the South San Francisco office and laboratory space in February 2019, we leased office and laboratory space in San Francisco, California under a sublease that expired on February 28, 2019. The leased location in San Francisco, California supported both the HBV and Microbiome programs. We also conducted research, development and small-scale manufacturing activities for the Microbiome program at office and laboratory space in Groton, Connecticut under a lease that expires in March 2021. 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 this lease.

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 February 22, 2021, there were 67 stockholders of record, which excludes stockholders whose shares were held in nominee or street name by brokers.

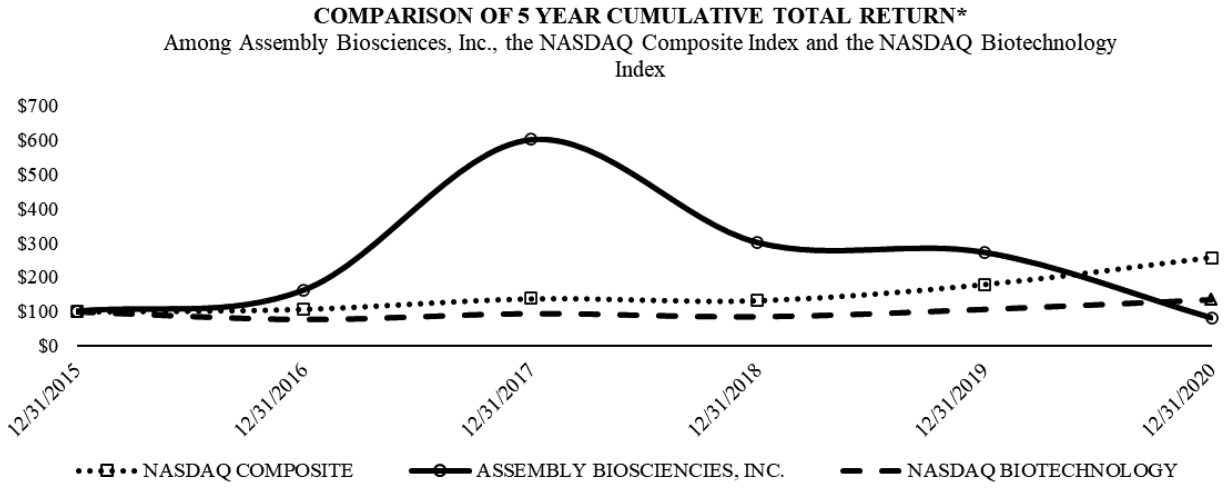
Dividend Policy

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

Comparative Stock Performance Graph

The information included under the heading "Comparative Stock Performance Graph" in this Item 5 of Part II of this Form 10-K shall not be deemed to be "soliciting material" or subject to Regulation 14A or 14C, shall not be deemed "filed" for purposes of Section 18 of the Exchange Act, or otherwise subject to the liabilities of that section, nor shall it be deemed incorporated by reference in any filing under the Securities Act or the Exchange Act.

Set forth below is a graph comparing the total cumulative returns of our common stock, the Nasdaq Composite Index and the Nasdaq Biotechnology Index. The graph assumes $100 was invested in our common stock and each of the indices on December 31, 2015 and that all dividends, if any, are reinvested.



* $100 invested on December 31, 2015 in stock or index, including reinvestment of dividends.

	12/31/2015	12/31/2016	12/31/2017	12/31/2018	12/31/2019	12/31/2020
Assembly Biosciences, Inc.	100.00	161.78	602.53	301.20	272.44	80.56
Nasdaq Composite	100.00	107.50	137.86	132.51	179.19	257.38
Nasdaq Biotechnology	100.00	78.32	94.81	85.97	106.95	134.42

Securities Authorized for Issuance Under Equity Compensation Plans

The following table sets forth the indicated information as of December 31, 2020 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	5,515,752	[2]	$ 14.39	2,355,332	[3]
Equity compensation plans not approved by securityholders	2,067,708	[4]	$ 18.86	24,020	[5]
Total	7,583,460			2,379,352	

(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: 363,161 shares subject to stock options granted under the 2010 Equity Incentive Plan (2010 Plan); 2,453,335 shares subject to outstanding awards granted under the Assembly Biosciences, Inc. Amended and Restated 2014 Stock Incentive Plan (2014 Plan), of which 2,296,823 were subject to outstanding stock options and 156,512 were subject to outstanding RSUs; 2,269,503 shares subject to outstanding awards granted under the Assembly Biosciences, Inc. 2018 Stock Incentive Plan, as amended (2018 Plan), of which 1,608,912 were subject to outstanding stock options, 624,106 were subject to outstanding RSUs and 36,485 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. 2018 Employee Stock Purchase Plan (2018 ESPP).

(3) This number includes: no shares under the 2010 Plan, which has been frozen; 85,968 shares available for issuance under the 2014 Plan; 2,037,029 shares available for issuance under the 2018 Plan and; 232,335 shares reserved for issuance under the 2018 ESPP. As of February 22, 2021, assuming each participant purchases the maximum number of shares in the current offering period, no more than 51,000 shares are subject to purchase in the current offering, which ends on May 14, 2021.

(4) This number includes 791,028 shares subject to outstanding awards granted under the 2017 Inducement Award Plan (2017 Inducement Plan), of which 779,778 were subject to outstanding stock options and 11,250 were subject to outstanding RSUs; 500,000 shares subject to stock options granted under the 2019 Inducement Award Plan (2019 Inducement Plan).

(5) This number includes: 700 shares available for issuance under the 2017 Inducement Plan and no shares under the 2019 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. The 2018 ESPP provides for the purchase by employees of up to an aggregate of 400,000 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 warrants to purchase shares of our common stock issued to one consultant. In April 2017, our board of directors adopted the 2017 Inducement Plan and reserved 800,000 shares of our common stock for issuance under the Inducement Plan, and 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 Award Plan. The only persons eligible to receive grants of awards under the either the 2017 Inducement Plan or the 2019 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.

Recent Sales of Unregistered Securities

There were no unregistered sales of equity securities in 2020.

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. Selected Financial Data

The following selected balance sheet data for the years ended December 31, 2020 and 2019 and the statement of operations data for the years ended December 31, 2020, 2019 and 2018 should be read in conjunction with Part II, Item 7 "Management's Discussion and Analysis of Financial Condition and Results of Operations" and in conjunction with the consolidated financial statements, related notes and other financial information included elsewhere in this Annual Report. The selected consolidated results of operation data for the years ended December 31, 2017 and 2016 and the balance sheet data for the years ended December 31, 2018, 2017 and 2016 have been derived from audited consolidated financial statements not included herein. Our historical results are not necessarily indicative of the results to be expected in the future.

	December 31,				
($ in thousands except for per share amounts)	**2020**	**2019**	**2018**	**2017**	**2016**
Balance Sheet Data:					
Total assets	$ 283,254	$ 339,907	$ 268,045	$ 169,303	$ 98,119
Total stockholders' equity	240,578	273,217	210,653	113,120	79,878
Statement of Operations Data:					
Collaboration revenue	$ 79,105	$ 15,963	$ 14,804	$ 9,019	$ —
Operating expenses	143,881	118,676	107,539	61,246	45,278
Loss from operations	(64,776)	(102,713)	(92,735)	(52,227)	(45,278)
Interest and other income, net	2,624	4,295	3,083	368	399
Loss before income taxes	(62,152)	(98,408)	(89,652)	(51,859)	(44,879)
Income tax (expenses) benefit	—	774	(1,099)	9,050	618
Net loss	$ (62,152)	$ (97,634)	$ (90,751)	$ (42,809)	$ (44,261)
Unrealized gain/loss on marketable securities, net of tax	(69)	146	45	209	221
Basic and dilutive loss per share	$ (1.75)	$ (3.72)	$ (3.98)	$ (2.41)	$ (2.57)

The increase in total assets from $98.1 million as of December 31, 2016 to $169.3 million as of December 31, 2017 was primarily due to a capital raise of $64.8 million in net proceeds in November 2017 and receipt from Allergan of an upfront payment of $50.0 million in February 2017. The increase in total assets from $169.3 million as of December 31, 2017 to $268.0 million as of December 31, 2018 was primarily due to a capital raise of $155.4 million in net proceeds to us in July 2018. The increase in total assets from $268.0 million as of December 31, 2018 to $339.9 million as of December 31, 2019 is primarily due to a capital raise of $134.7 million in net proceeds in December 2019. The decrease in total assets from $339.9 million as of December 31, 2019 to $283.3 million as of December 31, 2020 is primarily due to cash used in operations. Our operating expenses have increased year over year primarily due to increases in research and development activities and an increase in our total headcount. See Part II, Item 7 "Management's Discussion and Analysis of Financial Condition and Results of Operations" for a discussion on results of operations and financing activities since 2018.

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 "Selected Financial Data", 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 clinical-stage biotechnology company advancing a novel class of oral therapeutic candidates for the treatment of chronic hepatitis B virus (HBV) infection. According to the World Health Organization (WHO), approximately 270 million people worldwide are chronically infected with HBV. Our research and development programs are pursuing multiple drug candidates designed to inhibit the HBV replication cycle and block the generation of covalently closed circular DNA (cccDNA), with the aim of discovering and developing finite and curative therapies for patients with HBV. We have discovered several novel core inhibitors, which are small molecules that directly target and allosterically modulate the HBV core (HBc) protein in a way that affects assembly and stability of HBV nucleocapsids.

The ongoing COVID-19 pandemic has affected certain aspects of our business. As further detailed below, those effects have been primarily limited to where and how our employees work in our labs and offices. To date, our current and future planned clinical trials and pre-clinical studies have not been subject to significant impact as a result of the COVID-19 pandemic.

As previously announced, in January 2021, we wound down our Microbiome program to prioritize and focus our resources on discovering and developing finite and curative therapies for HBV. Our Microbiome program had been developing a novel class of oral live microbial biotherapeutics candidates designed to treat disorders associated with the microbiome.

Our Primary Focus: Targeting HBV Core Protein to Achieve a Cure

HBV is a DNA virus that infects hepatocytes and establishes a reservoir of cccDNA, a unique 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, most of our research and development efforts to date have focused on discovering and developing compounds targeting the core protein, a highly conserved viral structural protein that has no human homologue and is 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 core inhibitors that directly target and allosterically inhibit core protein functions.

Vebicorvir

Vebicorvir (VBR), our lead core inhibitor product candidate, is licensed from Indiana University. The conduct of the Phase 2 studies, Study 201 and 202 and our open-label extension study, Study 211, are all complete. We presented interim updates on our clinical studies at a variety of conferences, including at the European Association for the Study of the Liver's (EASL) Digital International Liver Congress™ in August 2020 and the American Association for the Study of Liver Diseases (AASLD) Annual Meeting in November 2020.

Our most recently completed study for VBR, Study 211, involved transitioning patients who met the requisite stopping criteria, as determined with our lead investigators and the U.S. Food and Drug Administration (FDA), off of therapy to test for sustained virologic response (SVR). SVR refers to sustained viral suppression (more than six months) of HBV DNA below the lower limit of quantification (LLOQ) and would be consistent with a successful finite treatment for HBV. In November 2020, it became clear that patients who stopped therapy in Study 211 had not achieved meaningful SVR rates as 39 of 41 patients relapsed, meaning they had detectable HBV. We continue to collect and analyze Study 211 data and intend to submit more detailed findings to a future medical meeting; however, it is clear that combination therapy of VBR plus nucelos(t)ide analog reverse transcriptase inhibitors (NrtI) alone is not sufficient to cure HBV. Based on these results, we terminated Study 211 prior to its completion.

Based on discussions with leading viral hepatitis experts, global regulatory discussions and feedback, and, with respect to the China territory, discussions and agreement with our collaboration partner, BeiGene, Ltd. (BeiGene),

we recently decided to not move forward with the global registrational studies for VBR as a chronic suppressive treatment (CST) with NrtI. The decision was made to focus on the greatest unmet medical need of patients, which lies predominantly in cure, rather than CST. As a result, we also expect to terminate Study 205, as we focus our efforts with VBR moving forward in combination with NrtI and additional mechanisms targeting finite and curative combination therapy.

ABI-H2158

Our second-generation core inhibitor product candidate, ABI-H2158 (2158), was internally discovered and developed and is chemically distinct from VBR.

We reported the final data from dose-ranging cohorts of the Phase 1b portion of the Phase 1a/1b dose-ranging clinical study at EASL in August 2020. Based on data from the Phase 1b dose-ranging study, we initiated a Phase 2 clinical study in June 2020 using a 300 mg daily dose of 2158. This study is being conducted in approximately ten countries in Asia, North America and Europe. We expect interim data from this study in the second half of 2021. While we will continue to monitor the situation closely, at this time, we do not expect our timelines for this study to be significantly impacted by the COVID-19 pandemic.

ABI-H3733

Our third core inhibitor product candidate, ABI-H3733 (3733), has completed Investigational New Drug (IND) enabling studies. 3733 has a novel chemical scaffold separate from both VBR and 2158. We presented a preclinical profile of this candidate in the first quarter of 2019.

In the first quarter of 2020, we initiated a Phase 1a clinical study to evaluate safety, tolerability and pharmacokinetics (PK) following single ascending dose and multiple ascending dose administration of 3733 in healthy subjects in New Zealand. Conduct for the study was completed in the fourth quarter of 2020 and preliminary data indicate that 3733 was generally well-tolerated and had favorable PK.

Additional Product Candidates

In addition to our three clinical-stage product candidates, our research discovery team is actively focused on identifying and selecting a fourth-generation core inhibitor candidate, which we anticipate in the first half of 2021.

Multi-Drug Combination Studies

We believe that core inhibitors and NrtI will be central to finite and curative therapies for chronic HBV infection. Therefore, as we continue to develop and advance our current and future core inhibitors through clinical studies, we plan to conduct multi-drug combination studies in parallel that add additional drugs (or compounds) with non-overlapping mechanisms of action to the core inhibitor + NrtI antiviral backbone. Specifically, we plan on only incorporating our current and future core inhibitors that have demonstrated they are well-tolerated and effective in clinical studies in dual combination with NrtI. As the 300 mg daily dose of VBR has been observed to be well-tolerated in all studies conducted to date, with no serious adverse effects or dose-limiting toxicities identified and no pattern of treatment-emergent clinical or laboratory abnormalities observed and has progressed beyond dual combination studies, we currently have two triple combination studies planned to study VBR in combination with NrtI and a third mechanism of action.

Beyond Core Inhibitors

In addition to the development and advancement of our core inhibitor portfolio and our current and future multi-drug combination studies, our research and development team is working on discovering and developing a potent fourth-generation core inhibitor, cccDNA disruptors and small molecules targeting novel undisclosed targets to add to the core inhibitor + NrtI antiviral backbone to achieve cure.

Operations

We currently have corporate and administrative offices and research laboratory space in South San Francisco, California, Groton, Connecticut and a small office 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 continue to develop our product candidates. As of December 31, 2020, we had an accumulated deficit of $501.6 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.

Financial Operations Overview

Research and Development Expense

Research and development expenses consist primarily of costs incurred for our research activities, including our drug discovery efforts, target validation, lead optimization and the development of our product candidates, which include:

- employee-related expenses including salaries, benefits, and stock-based compensation expense;
- expenses incurred under agreements with third parties, including contract research organizations (CROs) that conduct research and development, nonclinical and clinical activities on our behalf and the cost of consultants, and contract manufacturing organizations (CMOs) that manufacture all of our drug substance and the drug product used in our HBV program;
- the cost of lab supplies and acquiring, developing, and manufacturing nonclinical and, in the case of our Microbiome program, early stage clinical study materials;
- fees related to our license agreements; and
- facilities, depreciation, and other expenses, which include direct and allocated expenses for rent and maintenance of facilities, insurance, and other operating costs.

Research and development costs are expensed as incurred. Nonrefundable advance payments for goods or services to be received in the future for use in research and development activities are deferred and capitalized. The capitalized amounts are expensed as the related goods are delivered or the services are rendered.

We use our employee and infrastructure resources across multiple research and development programs, and we allocate internal employee-related and infrastructure costs, as well as certain third-party costs, to each of our programs based on the personnel resources allocated to such program. Our research and development expenses, by major program, are outlined in the table below (in thousands):

	Year Ended December 31,		
	2020	2019	2018
HBV[(1)]	$ 71,957	$ 57,534	$ 49,416
Microbiome[(2)]	34,866	28,223	23,325
Total	$ 106,823	$ 85,757	$ 72,741

(1) Expenses presented for HBV include reimbursement of expenses of $0.2 million under the Clinical Trial Collaboration Agreement (Arbutus Agreement) with Arbutus Biopharma Corporation (Arbutus), as discussed in Note 9 to the Consolidated Financial Statements.

(2) Expenses presented for Microbiome do not reflect reimbursement of expenses under the Research, Development, Collaboration and License Agreement (Allergan Agreement) with Allergan Pharmaceuticals International Limited (Allergan), as discussed in Note 9 to the Consolidated Financial Statements.

The successful discovery and development of our product candidates is highly uncertain. As such, at this time, we cannot reasonably estimate, or know the nature, timing and estimated costs, of the efforts that will be necessary to complete the remainder of their development. We are also unable to predict when, if ever, material net cash inflows will commence from our product candidates. This is due to the numerous risks and uncertainties associated with developing medicines, including the uncertainty of:

- the timing, progress and success of our clinical trials and research discovery team in identifying new product candidates;
- establishing an appropriate safety profile with IND-enabling toxicology studies sufficient to advance additional product candidates into clinical development;
- successful enrollment in, and completion of, clinical studies;
- making arrangements with third-party manufacturers; and
- obtaining and maintaining patent and trade secret protection and regulatory exclusivity for our product candidates.

A change in the outcome of any of these variables or variables discussed in "Item 1A. Risk Factors" with respect to the development of any of our product candidates would significantly change the costs and timing associated with the development of that product candidate.

Research and development activities are central to our business model. Product candidates in later stages of clinical development generally have higher development costs than those in earlier stages of clinical development, primarily due to the increased size and duration of later-stage clinical studies. However, we do not believe that it is possible at this time to accurately project total program-specific expenses through commercialization. There are numerous factors associated with the successful commercialization of any of our product candidates, including future trial design and various regulatory requirements, many of which cannot be determined with accuracy at this time based on our stage of development. Additionally, future commercial and regulatory factors beyond our control will impact our clinical development programs and plans.

General and administrative expenses

General and administrative expenses consist primarily of salaries and other related costs, including stock-based compensation, for personnel in executive, finance, accounting, business development, 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.

We anticipate that our general and administrative expenses will increase in the future to support continued research and development activities, potential commercialization of our product candidates and costs of operating as a public company. These increases will likely include increased costs related to the hiring of additional personnel and fees to outside consultants, lawyers and accountants, among other expenses. Additionally, we anticipate increased costs associated with being a public company, including expenses related to services associated with maintaining compliance with exchange listing and U.S. Securities and Exchange Commission (SEC) requirements, insurance, and investor relations costs.

Interest income

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

Critical Accounting Policies and Significant Judgments and 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. 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.

While our significant accounting policies are described in more detail in the notes to our consolidated financial statements included elsewhere in this Annual Report on Form 10-K, we believe that the following accounting policies are the most critical to aid you in fully understanding and evaluating our financial condition and results of operations.

Revenue Recognition and Accounts Receivable from Collaboration

We analyze our 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, we consider 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 our consolidated statements of operations and comprehensive loss.

Under certain collaborative arrangements, we are reimbursed for a portion of our research and development expenses or participate 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 our consolidated statements of operations and comprehensive loss, as we do not consider performing these activities for reimbursement to be a part of our 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, we evaluate the term of the arrangement and recognize revenue when the customer obtains control of promised goods or services in a contract for an amount that reflects the consideration we expect to receive in exchange for those goods or services. For contracts with customers, we apply 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) we satisfy each performance obligation.

We have provided standard indemnification and protection of licensed intellectual property for our customers. These provisions are part of assurance that the licenses meet the agreements, representations and are not obligations to provide goods or services.

We only apply the five-step model to contracts when it is probable we will collect the consideration we are entitled to in exchange for the goods or services it transfers to the customer. As part of the accounting for contracts with customers, we must develop assumptions that require judgment to determine the standalone selling price of each performance obligation identified in the contract. We then allocate the total transaction price to each performance obligation based on the estimated standalone selling prices of each performance obligation. We recognize 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 our intellectual property is determined to be distinct from the other performance obligations identified in the arrangement, we recognize 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, we utilize 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, we apply an appropriate method of measuring progress for purposes of recognizing revenue from nonrefundable, upfront license fees. We evaluate the measure of progress each reporting period and, if necessary, adjust the measure of performance and related revenue recognition.

Research and Development Service Payments

Under the Allergan Agreement, we were reimbursed at a certain percentage for performing research and development services based on hours worked by our employees at a fixed contractual rate per hour and third-party pass-through costs we incurred on a quarterly basis. Research and development service payments were included in the transaction price in the reporting period we concluded it was probable that recording revenue in the period would not result in a significant reversal in amounts recognized in future periods. Accounts receivable were recorded when the right to the research and development service payment consideration became unconditional. We recorded the full reimbursed portion of these expenses accounted for under the contract with customer accounting standard as collaboration revenue in our consolidated statements of operations as we consider performing research and development services to be a part of our ongoing and central operations.

Development and Regulatory Milestone Payments

Depending on facts and circumstances, we may record revenues from certain milestones in a reporting period before the milestone is achieved if we conclude that achievement of the milestone is probable and that recognition of revenue related to the milestone will not result in a significant reversal in amounts recognized in future periods. We record 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. We re-evaluate the probability of achievement of such milestones and any related constraint each reporting period. We adjust our estimate of the overall transaction price, including the amount of collaborative revenue that was recorded, if necessary.

Sales-based Milestone and Royalty Payments

Our customer may be required to pay us sales-based milestone payments or royalties on future sales of commercial products. We recognize revenues related to sales-based milestone and royalty payments upon the later to occur of (1) achievement of the collaborator's underlying sales or (2) satisfaction of any performance obligation(s) related to these sales, in each case assuming our licensed intellectual property is deemed to be the predominant item to which the sales-based milestones and/or royalties relate.

We receive payments from our customer based on billing schedules established in each contract. Upfront payments and fees are recorded as deferred revenue upon receipt or when due until we perform our obligations under the arrangement. If the related performance obligation is expected to be satisfied within the next 12 months, these amounts will be classified in current liabilities. We recognize a contract asset relating to our conditional right to consideration that is not subject to a constraint. Amounts are recorded as accounts receivable when our right to consideration is unconditional.

A net contract asset or liability is presented for each contract with a customer. We do 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.

We may be required to exercise considerable judgment in estimating revenue to be recognized. Judgment is required in identifying performance obligations, estimating the transaction price, estimating the standalone selling prices of identified performance obligations, which may include forecasted revenue, development timelines, reimbursement rates for personnel and other research and development costs, discount rates and probabilities of technical and regulatory success, and estimating the progress towards satisfaction of performance obligations.

On January 1, 2018, we adopted ASU No. 2014-09, *Revenue from Contracts with Customers*, as amended (Accounting Standards Codification Topic 606) (ASC 606) using the modified retrospective method applied to those contracts which were not completed as of January 1, 2018. We also elected to use the practical expedient that allows

an entity to expense the incremental cost of obtaining a contract as an expense when incurred if the amortization period of the asset that an entity otherwise would have recognized is less than one year. Results for the year ended December 31, 2018 are presented under ASC 606, while prior period amounts are not adjusted and continue to be reported in accordance with historic accounting under the previous revenue recognition accounting standard. As of the adoption date of ASC 606, we had only one contract with a customer, Allergan, that had not been completed. Based on our analysis, we concluded there was no significant change in applying ASC 606 to our agreement with Allergan and no amounts have been recognized within "accumulated deficit" in the consolidated balance sheet related to the adoption of the new standard.

Goodwill and Indefinite-Lived Intangible Assets

Goodwill and indefinite-lived intangible assets are reviewed for impairment at least annually in the fourth quarter and more frequently if events or other changes in circumstances indicate that the carrying amount of the assets may not be recoverable. Impairment of goodwill and indefinite-lived intangibles is determined to exist when the fair value is less than the carrying value of the net assets being tested.

Goodwill

We determined that we have only one operating segment and reporting unit. Accordingly, our review of goodwill impairment indicators is performed at the entity-wide level. In performing each annual impairment assessment and any interim impairment assessment, we determine if we should qualitatively assess whether it is more likely than not that the fair value of goodwill is less than its carrying amount (the qualitative impairment test). Some of the factors considered in the assessment include general macroeconomic conditions, conditions specific to the industry and market, cost factors, the overall financial performance and whether there have been sustained declines in our share price. If we conclude it is more likely than not that the fair value of the reporting unit is less than its carrying amount, or elect not to use the qualitative impairment test, a quantitative impairment test is performed. Effective January 1, 2020, we early adopted ASU 2017-04, *Intangibles-Goodwill and Other (Topic 350): Simplifying the Test for Goodwill Impairment* (ASU 2017-04), which simplifies how an entity is required to test goodwill for impairment by eliminating Step 2 from the goodwill impairment test. Under this accounting standard, annual or interim quantitative impairment testing is performed by comparing the estimated fair value of the reporting unit to its carrying value. An impairment charge is recognized for the amount by which the carrying amount exceeds the reporting unit's fair value, not to exceed the carrying value of goodwill. We use 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 that arise from control might cause the fair value of our reporting unit as a whole to exceed our market capitalization. However, we believe that 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 is based on control premiums observed in recent acquisitions of entities similar to us that were made on a non-minority basis. Should our market capitalization be less than our total stockholders' equity as of our annual test date or as of any interim impairment testing date, we would also consider market comparables, recent trends in our stock price over a reasonable period and, if appropriate, use an income approach (discounted cash flow) to determine whether the fair value of our reporting unit is greater than our carrying amount. If we were to use an income approach, we would establish a fair value by estimating the present value of our projected future cash flows expected to be generated from our business. The discount rate applied to the projected future cash flows to arrive at the present value would be 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 would consider projections of financial performance for a period of several years combined with an estimated residual value. The most significant assumptions we would use in a discounted cash flow methodology are the discount rate, the residual value and expected future revenues, gross margins and operating costs, along with considering any implied control premium. In 2020, we elected to bypass the qualitative goodwill impairment assessment. As of October 1, 2020, we have determined through a quantitative impairment test that the fair value significantly exceeded the carrying value of our single reporting unit, and concluded that goodwill was not impaired. In November 2020, after our public announcement that it became clear that patients who stopped therapy in Study 211 had not achieved meaningful SVR rates as 39 of 41 patients relapsed, our stock price declined 152% closing on November 5 at $15.90 and opening on November 6 at $6.30. Due to a sustained decline in our stock price during the remainder of the fourth quarter of 2020, we determined these factors were an indication of a triggering event of impairment and an interim goodwill impairment test was performed as of December 31, 2020. However, our interim quantitative impairment test still determined the fair value exceeded the carrying value of our single reporting unit and concluded that goodwill was still not impaired. We did not recognize any goodwill impairment in any of the years presented.

Indefinite-Lived Intangible Asset

Our indefinite-lived intangible asset consists of in-process research and development (IPR&D) projects acquired in a business combination that are used in research and development activities but have not yet reached technological feasibility, regardless of whether they have alternative future use. The primary basis for determining the technological feasibility or completion of these projects is obtaining regulatory approval to market the underlying products in an applicable geographic region. We classify in-process research and development acquired in a business combination as an indefinite-lived intangible asset until the completion or abandonment of the associated research and development efforts. Upon completion of the associated research and development efforts, we perform a final test for impairment and will 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 determine if we should qualitatively assess whether it is more likely than not that the fair value of our IPR&D asset is less than its carrying amount (the qualitative impairment test). If we conclude that is the case, or elect not to use 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 consider the results of the most recent quantitative impairment test and identify the most relevant drivers of the fair value for the IPR&D asset. The most relevant drivers of fair value we have identified are consistent with the assumptions used in the quantitative estimate of the IPR&D asset discussed below. Using these drivers, we identify events and circumstances that may have 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 weigh these factors to determine and conclude if it is not more likely than not that the IPR&D asset is impaired. If it is more likely than not that the IPR&D asset is impaired we proceed with quantitatively determining the fair value of the IPR&D asset.

We use the income approach to determine the fair value of our 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 includes significant 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 are 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 tax rates. Any impairment to be recorded is 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.

For our 2020 impairment test, we performed a qualitative test and concluded it was more-likely-than-not that the fair value of our IPR&D asset exceeded its carrying value and no further testing was required. This was based on a decrease in the probability of success based on the impact of the Study 211 and dual combination VBR and NrtI therapy's ability to serve as a finite and curative therapy for chronic HBV infection offset by an increase in the probability of success of 2158 and 3733 based on their advancement into Phase 2 and Phase 1 trials during 2020, respectively and the significance of the future net cash flows from potential drug sales for a finite and curative therapy for chronic HBV infection as primarily driven by the number of patients who will be diagnosed and treated and our competitive position in the marketplace. We did not recognize any IPR&D impairment in any of the years presented.

For asset purchases outside of business combinations, we expense any purchased research and development assets as of the acquisition date if they have no alternative future uses.

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 as well as research and development and costs incurred under our 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. Assets acquired as part of an asset acquisition that are used in research and development or are IPR&D are immediately expensed as research and development unless there is an alternative future use in other research and development projects.

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:

- CROs and other service providers in connection with clinical studies;
- 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 contract research organizations 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, 2020 and 2019.

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.

Restructuring Charges

We recognize restructuring charges related to reorganization plans that have been committed to by us and when liabilities have been incurred. In connection with these activities, we record 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 we have 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 us to make certain judgments and estimates regarding the nature, timing and amount of costs associated with the planned reorganization plan. To the extent the actual results differ from its estimates and assumptions, we 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 previously recognized. Such changes to previously estimated amounts may be material to our consolidated financial statements. Changes in the estimates of the restructuring charges are recorded in the period in which the change is determined.

At the end of each reporting period, we evaluate 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.

Off-Balance Sheet Arrangements

Since our inception, we have not engaged in any off-balance sheet arrangements.

Contractual Obligations

We have contractual and commercial obligations under our operating lease commitments and licenses. The following table summarizes our future contractual obligations and commercial commitments at December 31, 2020 (in thousands):

	Payments Due By Period				
	Less than 1 year	1-3 years	3-5 years	More than 5 years	Total
Operating lease obligations	$ 4,369	$ 7,407	$ —	$ —	$ 11,776
Total contractual obligations	$ 4,369	$ 7,407	$ —	$ —	$ 11,776

In general, milestone, royalty and other contingent fees associated with certain collaboration and license agreements have not been included in the above table of contractual obligations, because we cannot reasonably estimate if or when they will occur. The milestone payments included in the table of contractual obligations above are payments we believe are reasonably likely to occur during the indicated time periods. We enter into contracts in the normal course of business with CROs for clinical trials and CMO's 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, and therefore, are cancelable contracts and not included in the table above. Further, we anticipate that our operating lease obligations will be higher than projected as we renew existing real estate leases that expire in 2020 and enter into new or expanded real estate leases.

Results of Operations

General

At December 31, 2020, we had an accumulated deficit of $501.6 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 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 that we will ever generate significant revenues.

Comparison of the Years Ended December 31, 2020 and 2019

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
	2020	2019	2020 vs. 2019	2020 vs. 2019
Collaboration revenue	$ 79,105	$ 15,963	$ 63,142	396%

Collaboration revenue for the year ended December 31, 2020 includes the remaining deferred revenue balance of $37.0 million and reimbursements incurred under the Allergan Agreement, for which AbbVie Inc. gave written notice of termination in June 2020 following its acquisition of Allergan, and $31.0 million recognized for the transfer of the VBR License upon entering into the Collaboration Agreement with BeiGene (BeiGene Agreement).

Research and Development Expense

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
Program/Description	2020	2019	2020 vs. 2019	2020 vs. 2019
HBV[(1)]	$ 71,957	$ 57,534	$ 14,423	25%
Microbiome[(2)]	34,866	28,223	6,643	24%
Total research and development expenses	$ 106,823	$ 85,757	$ 21,066	25%

(1) Expenses presented for HBV include reimbursement of expenses of $0.2 million under the Arbutus Agreement, as discussed in Note 9 to the Consolidated Financial Statements.

(2) Expenses presented for the Microbiome program exclude collaboration revenue related to expense reimbursements under the Allergan Agreement as discussed in Note 9 to the Consolidated Financial Statements.

Research and development expenses were $106.8 million for the year ended December 31, 2020 compared to $85.8 million for the year ended December 31, 2019. The increase was due to an increase of $14.4 million in research and development expenses related to the HBV program and an increase of $6.6 million in research and development expenses related to the Microbiome program. These increases were primarily due to increases in clinical activities, chemistry and manufacturing control activities to support VBR, 2158, 3733 and Microbiome clinical trials and increased salary and benefits due to additional employees. In December 2020, we and our Board of Directors determined that it was in our best interest to wind down the Microbiome program, enabling us to prioritize resources and focus on the advancement of our pipeline of novel core inhibitors for chronic HBV infection. We expect to complete the wind-down of the Microbiome program in early 2021. Microbiome expenses for the year ended December 31, 2020 includes $5.5 million in restructuring costs related to the wind-down, which consists of $3.9 million in employee severance and related benefits and $1.6 million in asset impairment and other costs. Refer to Note 6 to the Consolidated Financial Statements for additional information. Research and development expenses include non-cash stock-based compensation expenses of $11.4 million for both the years ended December 31, 2020 and 2019.

General and Administrative Expense

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
	2020	2019	2020 vs. 2019	2020 vs. 2019
General and administrative expenses	$ 37,058	$ 32,919	$ 4,139	13%

General and administrative expense consists primarily of salaries, consulting fees and other related costs, professional fees for legal services, accounting and tax services, insurance and travel expenses, as well as stock-based compensation expense associated with equity awards to our employees, consultants and directors.

General and administrative expenses were $37.1 million for the year ended December 31, 2020, compared to $32.9 million for the year ended December 31, 2019. The increase in general and administrative expenses was primarily due to an increase of $3.1 million in professional expenses mostly attributable to the amortized incremental contract costs associated with entering into the BeiGene Agreement, $1.3 million in stock-based compensation expense, $0.5 million in equipment rental and $0.3 million in recruitment costs due to an increase in headcount partially offset by a decrease of $0.9 million in travel related expenses due to state and local laws restricting travel in response to the COVID-19 pandemic. General and administrative expenses includes non-cash stock-based compensation expense of $10.5 million and $9.2 million for the years ended December 31, 2020 and 2019, respectively. Stock-based compensation expense for the year ended December 31, 2020 includes the reversal of previously recognized expense of $1.7 million related to forfeited awards resulting from the departure of one of our former officers during the period, while stock-based compensation expense for the year ended December 31, 2019 includes the reversal of previously recognized expense of $3.6 million related to forfeited awards resulting from another our former officers during the period.

Interest and Other Income

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

	Year ended December 31,		$ Change	% Change
	2020	2019	2020 vs. 2019	2020 vs. 2019
Interest and other income	$ 2,624	$ 4,305	$ (1,681)	-39%

Interest and other income was $2.6 million for the year ended December 31, 2020 compared to $4.3 million for the same period in 2019. Interest income for the years ended December 31, 2020 and 2019 was primarily related to interest income earned on marketable securities, corporate bonds and money market funds and the decrease is a result of lower balances and lower yields carried in 2020.

Income Tax (Expense) Benefit

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

	Year ended December 31,		$ Change	% Change
	2020	2019	2020 vs. 2019	2020 vs. 2019
Income tax benefit	$ —	$ 774	$ (774)	-100%

Income tax benefit for the year ended December 31, 2020 was nominal compared to an income tax benefit for year ended December 31, 2019 of $0.8 million. The income tax benefit in the prior year is primarily due to a change in our state and local effective tax rate and recording the impact of certain indefinite-lived deferred tax asset carryforwards.

Comparison of the Years Ended December 31, 2019 and 2018

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
	2019	2018	2019 vs. 2018	2019 vs. 2018
Collaboration revenue	$ 15,963	$ 14,804	$ 1,159	8%

During the year ended December 31, 2019, we generated $16.0 million of collaboration revenue, which included the amortization of deferred revenue and reimbursement revenue in each case incurred under the Allergan Agreement, an increase of $1.2 million from $14.8 million for the same period in 2018. The increase was based on increased research efforts performed during 2019 for our Microbiome program.

Research and Development Expense

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
Program/Description	2019	2018	2019 vs. 2018	2019 vs. 2018
HBV[(1)]	$ 57,534	$ 49,416	$ 8,118	16%
Microbiome[(2)]	28,223	23,325	4,898	21%
Total research and development expenses	$ 85,757	$ 72,741	$ 13,016	18%

[(1)] Expenses presented for the Microbiome program exclude collaboration revenue related to expense reimbursements under the Allergan Agreement as discussed in Note 9 to the Consolidated Financial Statements.

Research and development expenses were $85.8 million for the year ended December 31, 2019 compared to $72.7 million for the year ended December 31, 2018. The increase was due to an increase of $8.1 million in research and development expenses related to the HBV program and an increase of $4.9 million in research and development expenses related to the Microbiome program. These increases were primarily due to increases in clinical activities, chemistry and manufacturing control activities to support VBR, 2158 and Microbiome clinical trials and increased salary and benefits due to additional employees. Research and development expenses include non-cash stock based compensation expenses of $11.4 million for the year ended December 31, 2019, a decrease of $0.4 million from $11.8 million for the year ended December 31, 2018.

General and Administrative Expense

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
	2019	2018	2019 vs. 2018	2019 vs. 2018
General and administrative expenses	$ 32,919	$ 34,798	$ (1,879)	-5%

General and administrative expense consists primarily of salaries, consulting fees and other related costs, professional fees for legal services, accounting and tax services, insurance and travel expenses, as well as stock-based compensation expense associated with equity awards to our employees, consultants and directors.

General and administrative expenses were $32.9 million for the year ended December 31, 2019, compared to $34.8 million for the year ended December 31, 2018. The increase in general and administrative expenses was primarily due to an increase of $3.5 million in employee related expenses due to the addition of employees in executive management, finance and human resources. This increase also includes a one-time expense of $1.7 million for severance packages in conjunction with the relocation of our corporate headquarters to South San Francisco, California effective January 1, 2020, the departure of one of our former executives, $0.9 million in rent expenses for our new office in South San Francisco and $0.3 million in professional expenses.

Stock-based compensation expense was $9.2 million for the year ended December 31, 2019, a decrease of $7.5 million from $16.7 million for the year ended December 31, 2018. The decrease was primarily due to a $4.3 million one-time expense related to the departure and transition to consultant of one of our former executive officers in 2018 coupled with the reversal of previously recognized expense of $3.6 million related to forfeited awards resulting from the departure of one of our former executive officers in 2019.

Interest and Other Income

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

	Year ended December 31,		$ Change	% Change
	2019	2018	2019 vs. 2018	2019 vs. 2018
Interest and other income	$ 4,305	$ 3,083	$ 1,222	40%

Interest and other income was $4.3 million for the year ended December 31, 2019 compared to $3.1 million for the same period in 2018. Interest income for the years ended December 31, 2019 and 2018 was primarily related to interest income earned on marketable securities, corporate bonds and money market funds, and the increase is a result of higher balances carried in 2019.

Income Tax (Expense) Benefit

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

	Year ended December 31,		$ Change	% Change
	2019	2018	2019 vs. 2018	2019 vs. 2018
Income tax benefit (expense)	$ 774	$ (1,099)	$ 1,873	170%

Income tax benefit for the year ended December 31, 2019 was $0.8 million compared to an income tax expense for year ended December 31, 2018 of $1.1 million. The income tax benefit in 2019 is primarily due to a change in our state and local effective tax rate and recording the impact of certain indefinite-lived deferred tax asset carryforwards. The income tax expense recognized in 2018 is primarily due to a change in our state and local effective tax rate.

Liquidity and Capital Resources

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, 2020 principally with debt prior to our initial public offering, and thereafter with equity financing, raising an aggregate of $551.8 million in net proceeds from public offerings and private placements from inception to December 31, 2020. Additionally, in February 2017, we received a $50.0 million upfront payment in connection with the execution of the Allergan Agreement and in July 2020, we received a $40.0 million upfront payment in connection with the execution of the BeiGene Agreement.

In July 2018, we sold to various investors an aggregate of 4,600,000 shares of common stock in a public offering at $36.00 per share, which included the exercise in full by the underwriters of their option to purchase 600,000 additional shares of common stock. We received aggregate net proceeds of $155.4 million from the offering and the option exercise, after deducting underwriting discounts and commissions and offering expenses payable.

In December 2019, we sold to various investors an aggregate of 6,287,878 shares of common stock at a public offering price of $16.50 per share, which included the exercise in full by the underwriters of their option to purchase 1,136,363 shares of common stock, and pre-funded warrants to purchase 2,424,242 shares of common stock at a public offering price of $16.499. We received aggregate net proceeds of $134.7 million from the offering and the option exercise, after deducting underwriting discounts and commissions and offering expenses payable.

In December 2020, we sold an aggregate of 892,840 shares of common stock through "at-the-market" offerings (2020 ATM), resulting in net proceeds of $5.5 million.

Cash Flows

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

	Year Ended December 31,		
	2020	**2019**	**2018**
Operating activities	$ (62,957)	$ (84,067)	$ (64,958)
Investing activities	68,070	(50,318)	(135,397)
Financing activities	7,599	139,646	159,793
Net increase (decrease) in cash and cash equivalents	$ 12,712	$ 5,261	$ (40,562)

Net Cash Used in Operating Activities

Net cash used in operating activities was $63.0 million for the year ended December 31, 2020. This was primarily due to $62.2 million of net loss and a decrease of $30.3 million of operating assets and liabilities, which were offset by a $21.9 million non-cash expense recorded for stock-based compensation, $5.2 million of amortization of operating lease right-of-use assets, $1.8 million in non-cash expense for acquired IPR&D and $0.7 million of depreciation and amortization expense.

Net cash used in operating activities was $84.1 million for the year ended December 31, 2019. This was primarily due to $97.6 million of net loss, a decrease of $9.5 million of operating assets and liabilities, $0.8 million of deferred income tax benefit and $1.7 million of amortization of discount on marketable securities, which were offset by a $20.6 million non-cash expense recorded for stock-based compensation, $4.5 million of amortization of operating lease right-of-use assets and $0.5 million of depreciation and amortization expense.

Net cash used in operating activities was $65.0 million for the year ended December 31, 2018. This was primarily due to $90.8 million of net loss, a decrease of $4.2 million of operating assets and liabilities and $0.2 million of amortization of discount on marketable securities, which were offset by a $28.5 million non-cash expense recorded for stock-based compensation, $0.6 million of depreciation and amortization expense and $1.1 million of deferred income tax expenses.

Net Cash Provided by (Used in) Investing Activities

Net cash provided by investing activities for the year ended December 31, 2020 was $68.1 million primarily due to a purchase of $193.2 million marketable securities, $0.5 million of fixed assets and $1.8 million of IPR&D, which were offset by $221.6 million for the redemption of marketable securities and $41.9 million for the sale of marketable securities.

Net cash used in investing activities for the year ended December 31, 2019 was $50.3 million primarily due to a purchase of $281.3 million marketable securities and $1.6 million of fixed assets, which were offset by $203.9 million for the redemption of marketable securities and $28.7 million for the sale of marketable securities.

Net cash used in investing activities for the year ended December 31, 2018 was $135.4 million primarily due to a purchase of $183.9 million marketable securities and $0.3 million of fixed assets and construction in progress, which were offset by $48.9 million for the redemption of marketable securities.

Net Cash Provided by Financing Activities

Net cash provided by financing activities for the year ended December 31, 2020 was $7.6 million resulting from the net proceeds of $5.5 million from the sale of 892,840 shares of our common stock under the 2020 ATM, $1.5 million from the exercise of stock options to purchase 175,579 shares of common stock and $0.7 million from the issuance of 86,812 shares of common stock under our 2018 ESPP.

Net cash provided by financing activities for the year ended December 31, 2019 was $139.6 million resulting from the net proceeds of $134.7 million from our public offering of 6,287,878 shares of common stock and 2,424,242 pre-funded warrants to purchase 2,424,242 shares of common stock at a public offering price of $16.499, including 1,136,363 shares of common stock purchased by the underwriters pursuant to their 30-day option to purchase additional shares, $4.2 million from the exercise of stock options to purchase 585,292 shares of common stock and $0.7 million from the issuance of 59,370 shares of common stock under our 2018 ESPP.

Net cash provided by financing activities for the year ended December 31, 2018 was $159.8 million, resulting from the net proceeds of $155.4 million from our public offering of 4,600,000 shares of common stock, including 600,000 shares of common stock purchased by the underwriters pursuant to their 30-day option to purchase additional shares, and $4.0 million from the exercise of stock options to purchase 775,224 shares of common stock.

Future Funding Requirements

We expect our expenses related to HBV program to remain flat in 2021 but to generally increase over time in connection with our ongoing activities, particularly as we continue the research, development and clinical studies of our product candidates and pursue our intellectual property strategy. Accordingly, 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, most recently in December 2020. 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 that 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 future capital requirements will depend on many factors, including:

- 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;
- the extent to which we further acquire or in-license other product candidates and technologies;
- 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.

Recent Accounting Pronouncements

See Note 2 of notes to the consolidated financial statements for a discussion of recent accounting standards and pronouncements.

Cautionary Statement

We operate in a highly competitive environment that involves a number of risks, some of which are beyond our control. The following statement highlights some of these risks. For more detail, see “Item 1A. Risk Factors.”

Statements contained in this Form 10-K that are not historical facts, are or might constitute forward-looking statements under the safe harbor provisions of the Private Securities Litigation Reform Act of 1995. Although we believe the expectations reflected in such forward-looking statements are based on reasonable assumptions, our expectations might not be attained. Forward-looking statements involve known and unknown risks that could cause actual results to differ materially from expected results. Factors that could cause actual results to differ materially from our expectations expressed in the report include, among others: risks related to the costs, timing, regulatory review and results of our nonclinical studies and clinical studies; our ability to obtain FDA approval of our product candidates; our anticipated capital expenditures, our estimates regarding our capital requirements, and our need for future capital; our liquidity and working capital requirements; our expectations regarding our revenues, expenses and other results of operations; the unpredictability of the size of the markets for, and market acceptance of, any of our products; our ability to sell any approved products and the price we are able realize; our ability to establish and maintain collaborations on favorable terms; our ability to obtain future funding on acceptable terms; our ability to hire and retain necessary employees and to staff our operations appropriately; our ability to compete in our industry and innovation by our competitors; our ability to stay abreast of and comply with new or modified laws and regulations that currently apply or become applicable to our business; estimates and estimate methodologies used in preparing our financial statements; the future trading prices of our common stock and the impact of securities analysts’ reports on these prices; and the risks set out in our filings with the SEC.

Item 7A. Quantitative and Qualitative Disclosures about Market Risk

Our primary exposure to market risk is interest income sensitivity, which is affected by changes in the general level of U.S. interest rates.

We do not believe that our cash and equivalents have significant risk of default or illiquidity. Under our current investment policies, we invest our cash and cash equivalents in money market funds which invest in short-term U.S. Treasury securities with insignificant rates of return. We also invest our cash and cash equivalents in readily marketable, high-quality securities that are diversified and structured to minimize market risks. Our exposure to market risk for changes in interest rates relates primarily to our investments in marketable securities. Marketable securities held in our investment portfolio are subject to changes in market value in response to changes in interest rates and liquidity. A significant change in market interest rates could have a material impact on interest income earned from our investment portfolio. Changes in interest rates may affect the fair value of our investment portfolio; however, we will not recognize such gains or losses in our statement of operations and comprehensive income (loss) unless the investments are sold.

While we believe our cash and equivalents do not contain excessive risk, we cannot provide absolute assurance that in the future our investments will not be subject to adverse changes in market value. In addition, we maintain significant amounts of cash and equivalents at one or more financial institutions that are in excess of federally insured limits.

Inflation generally affects us by increasing our cost of labor and clinical study costs. We do not believe that inflation has had a material effect on our results of operations during 2020, 2019 or 2018.

Item 8. Financial Statements and Supplementary Data

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.

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, 2020, we carried out an evaluation, under the supervision, and with the participation of, our management, including our Chief Executive Officer and our Chief 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 and Chief Financial Officer concluded that our disclosure controls and procedures for the fiscal year ending as of December 31, 2020 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 and our Chief 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, 2020.

Our independent registered public accounting firm, Ernst & Young LLP has issued an opinion on the effectiveness of our internal control over financial reporting as of December 31, 2020. The report of Ernst & Young LLP is included with the financial statements appended to this Form 10-K pursuant to Item 8.

Changes in Internal Control over Financial Reporting

There were no changes in our internal control over financial reporting in the fourth quarter of 2020 that materially affected, or are reasonably likely to materially affect, our internal control over financial reporting.

Item 9B. Other Information

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, 2020 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, which is included in Part II, Item 5 of this Annual Report on Form 10-K, 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 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 Accounting 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 registration statement:

Exhibit Number	Description of Document	Registrant's Form	Dated	Exhibit No.	Filed Herewith
3.1	Fifth Amended and Restated Certificate of Incorporation dated June 11, 2020.	8-K	06/01/2018	3.1	
3.2	Amended and Restated Bylaws as amended through January 22, 2021.	8-K	01/27/2021	3.1	
4.1	Specimen of Common Stock Certificate.	S-3	12/30/2015	4.1	
4.2	Form of Pre-Funded Warrant.	8-K	12/16/2019	4.1	
4.3	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	

Exhibit Number	Description of Document	Registrant's Form	Dated	Exhibit No.	Filed Herewith
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	
10.6#	Employment Agreement, dated August 6, 2019, between Assembly Biosciences, Inc. and John G. McHutchison, A.O., M.D.	10-Q	11/07/2019	10.1	
10.7#	Employment Agreement, dated September 30, 2019, between Assembly Biosciences, Inc. and Thomas J. Russo, effective as of October 28, 2019.	10-Q	11/07/2019	10.6	
10.8#	Amendment No. 1 to Employment Agreement, dated February 26, 2020, between Assembly Biosciences, Inc. and Thomas J. Russo.	10-Q	05/08/2020	10.6	
10.9#	Employment Agreement, dated October 22, 2019, between Assembly Biosciences, Inc. and Luisa M. Stamm, M.D., Ph.D. effective as of November 6, 2019.	10-K	03/04/2020	10.7	
10.10#	Amendment No. 1 to Employment Agreement, dated February 26, 2020, between Assembly Biosciences, Inc. and Luisa M. Stamm, M.D., Ph.D.	10-Q	05/08/2020	10.7	
10.11#	Employment Agreement, dated March 23, 2020, between Assembly Biosciences, Inc. and Jason A. Okazaki, effective as of March 26, 2020.				X
10.12#	Employment Agreement, dated May 1, 2020, between Assembly Biosciences, Inc. and William E. Delaney IV, Ph.D., effective as of May 27, 2020.				X
10.13#	2010 Equity Incentive Plan.	S-1/A	10/4/2010	10.14	
10.14#	Assembly Biosciences, Inc. Amended and Restated 2014 Stock Incentive Plan.	8-K	6/6/2016	10.1	
10.15#	Omnibus Amendment to Assembly Biosciences, Inc. Stock Incentive Plans.	10-Q	05/08/2020	10.2	
10.16#	Form of Notice of Stock Option Grant and Stock Option Agreement under Amended and Restated 2014 Stock Incentive Plan.	S-8	9/17/2014	10.28	
10.17#	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	
10.18#	Assembly Biosciences, Inc. 2017 Inducement Award Plan.	10-Q	08/09/2017	10.1	
10.19#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2017 Inducement Award Plan.	10-Q	08/09/2017	10.2	
10.20#	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	
10.21#	Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	6/1/2018	10.1	
10.22#	Amendment No. 1 to Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	05/21/2019	10.2	
10.23#	Amendment No. 3 to Assembly Biosciences, Inc. 2018 Stock Incentive Plan.	8-K	06/16/2020	10.1	
10.24#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2018 Stock Incentive Plan.	8-K	6/1/2018	10.2	
10.25#	Form of Restricted Stock Unit Award Notice and Restricted Stock Unit Award Agreement under the 2018 Stock Incentive Plan.	8-K	6/1/2018	10.3	
10.26#	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	

Exhibit Number	Description of Document	Registrant's Form	Dated	Exhibit No.	Filed Herewith
10.27#	Assembly Biosciences, Inc. 2018 Employee Stock Purchase Plan.	8-K	6/1/2018	10.4	
10.28#	Assembly Biosciences, Inc. 2019 Inducement Award Plan.	10-Q	11/07/2019	10.4	
10.29#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2019 Inducement Award Plan.	10-Q	11/07/2019	10.5	
10.30#	Assembly Biosciences, Inc. 2020 Inducement Award Plan.	10-Q	05/08/2020	10.3	
10.31#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2020 Inducement Award Plan.	10-Q	05/08/2020	10.4	
10.32#	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	
10.33#	Assembly Biosciences, Inc. 2020 Corporate Bonus Plan.	8-K	02/11/2020	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
31.2	Certification of the Chief Financial 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
32.2**	Certification of the Chief Financial 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.				
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 that are both not material and would likely cause competitive harm to the registrant if publicly disclosed have been omitted pursuant to Item 601(b)(10)(iv) of Regulation S-K.

Represents management contracts or compensatory plans or arrangements.

** The certifications attached as Exhibits 32.1 and 32.2 that accompany this Annual Report on Form 10-K are to be deemed furnished and shall not be deemed "filed" with the SEC and are 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: February 25, 2021

By: /s/ John G. McHutchison, A.O., M.D.
Name: John G. McHutchison, A.O., M.D.
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 John G. McHutchison, A.O., M.D., Thomas J. Russo, CFA and Jason A. Okazaki, 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/ John G. McHutchison, A.O., M.D. John G. McHutchison, A.O., M.D.	Chief Executive Officer, President and Director (Principal Executive Officer)	February 25, 2021
/s/ Thomas J. Russo, CFA Thomas J. Russo, CFA	Chief Financial Officer (Principal Financial and Principal Accounting Officer)	February 25, 2021
/s/ William R. Ringo, Jr. William R. Ringo, Jr.	Chairman of the Board	February 25, 2021
/s/ Anthony E. Altig Anthony E. Altig	Director	February 25, 2021
/s/ Gina Consylman Gina Consylman	Director	February 25, 2021
/s/ Richard D. DiMarchi, Ph.D. Richard D. DiMarchi, Ph.D.	Director	February 25, 2021
/s/ Myron Z. Holubiak Myron Z. Holubiak	Director	February 25, 2021
/s/ Susan Mahony, Ph.D. Susan Mahony, Ph.D.	Director	February 25, 2021

[This page intentionally left blank]

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, 2020 and 2019, the related consolidated statements of operations and comprehensive loss, changes in stockholders' equity and cash flows for each of the three years in the period ended December 31, 2020, 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, 2020 and 2019, and the results of its operations and its cash flows for each of the three years in the period ended December 31, 2020, in conformity with U.S. generally accepted accounting principles.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (PCAOB), the Company's internal control over financial reporting as of December 31, 2020, based on criteria established in Internal Control—Integrated Framework issued by the Committee of Sponsoring Organizations of the Treadway Commission (2013 Framework) and our report dated February 25, 2021 expressed an unqualified opinion thereon.

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 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. 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 Matters

The critical audit matters communicated below are matters arising from the current period audit of the financial statements that were communicated or required to be communicated to the audit committee and that: (1) relate to accounts or disclosures that are material to the financial statements and (2) involved our especially challenging, subjective or complex judgments. The communication of critical audit matters 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 matters below, providing separate opinions on the critical audit matters or on the accounts or disclosures to which they relate.

Accrued clinical trial expenses

Description of the Matter

For the year ended December 31, 2020, the Company incurred $106.8 million of research and development expenses and recorded $4.4 million for accrued clinical trial expenses at December 31, 2020. As described in Note 2 to the consolidated financial statements, the Company's expense accruals for clinical trials are based on estimates of the services received and efforts expended pursuant to contracts with multiple contract research organizations (CROs) 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 to be expended in each period. At period end, accrued clinical trial 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. If possible, the Company obtains information regarding unbilled services 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 clinical trial 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 clinical trial 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

We obtained an understanding, evaluated the design and tested the operating effectiveness of controls over the Company's process for estimating the accrued clinical trial expenses including controls over management's assessment and measurement of clinical trial progress and related estimates of accrued clinical trial costs and the completeness and accuracy of underlying data used in the analysis.

To test the estimate of accrued clinical trial 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 assumptions 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.

Revenue Recognition for the Collaborative Arrangement with BeiGene, Ltd.

Description of the Matter

As described in Note 9 to the consolidated financial statements, in July 2020, the Company entered into a collaboration agreement with BeiGene, Ltd. (BeiGene) to develop and commercialize the Company's product candidates in China for the treatment of chronic Hepatitis B virus infection (the BeiGene Agreement). The BeiGene Agreement includes up-front fees, milestones, royalties, expense reimbursement, and potential cost share and profit sharing. Management was required to use judgment to determine what part of the BeiGene Agreement was within the scope of the contract with customers guidance and what part of the agreement was within the scope of the collaborative arrangement guidance. For the year ended December 31, 2020, the Company recognized $31.0 million as collaboration revenue and $9.0 million of long-term deferred revenue from the BeiGene Agreement.

Auditing the Company's accounting for revenues from its BeiGene Agreement was especially challenging due to the complex and highly judgmental nature of evaluating the terms of the agreement, evaluating whether analogies to the revenue accounting or collaborative arrangements guidance are appropriate, and allocating the transaction price to the performance obligations.

How We Addressed the Matter in Our Audit

We obtained an understanding, evaluated the design and tested the operating effectiveness of controls over management's assessment of the accounting treatment of the BeiGene Agreement and identification of performance obligations and application of the accounting guidance.

To test the accounting for revenue from the BeiGene Agreement, among other procedures, we tested and evaluated, the performance obligations identified and the allocation of transaction price to performance obligations. We also assessed whether management's evaluation of the portions of the BeiGene Agreement subject to the scope of the contract with customers accounting standard and collaborative arrangements accounting standard, as well as their analogies to the revenue from contracts with customers accounting standard or the portion of the BeiGene Agreement subject to the collaborative arrangements guidance, was an appropriate application of an accounting policy.

/s/ Ernst & Young LLP
We have served as the Company's auditor since 2015.

Redwood City, California
February 25, 2021

Report of Independent Registered Public Accounting Firm

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

Opinion on Internal Control over Financial Reporting

We have audited Assembly Biosciences, Inc.'s internal control over financial reporting as of December 31, 2020, based on criteria established in Internal Control—Integrated Framework issued by the Committee of Sponsoring Organizations of the Treadway Commission (2013 framework) (the COSO criteria). In our opinion, Assembly Biosciences, Inc. (the Company) maintained, in all material respects, effective internal control over financial reporting as of December 31, 2020, based on the COSO criteria.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (PCAOB), the consolidated balance sheets of the Company as of December 31, 2020 and 2019, the related consolidated statements of operations and comprehensive loss, changes in stockholders' equity and cash flows for each of the three years in the period ended December 31, 2020, and the related notes and our report dated February 25, 2021 expressed an unqualified opinion thereon.

Basis for Opinion

The Company's management is responsible for maintaining effective internal control over financial reporting and for its assessment of the effectiveness of internal control over financial reporting included in the accompanying Management's Annual Report on Internal Control Over Financial Reporting. Our responsibility is to express an opinion on the Company's internal control over financial reporting based on our audit. We are a public accounting firm registered with the 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 audit in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether effective internal control over financial reporting was maintained in all material respects.

Our audit included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, testing and evaluating the design and operating effectiveness of internal control based on the assessed risk, and performing such other procedures as we considered necessary in the circumstances. We believe that our audit provides a reasonable basis for our opinion.

Definition and Limitations of Internal Control Over Financial Reporting

A company's internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company's internal control over financial reporting includes those policies and procedures that (1) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company; (2) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (3) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company's assets that could have a material effect on the financial statements.

Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

/s/ Ernst & Young LLP

Redwood City, California
February 25, 2021

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

	As of December 31,	
	2020	**2019**
ASSETS		
Current assets		
Cash and cash equivalents	$ 59,444	$ 46,732
Marketable securities	156,969	227,311
Accounts receivable from collaborations	1,230	3,374
Prepaid expenses and other current assets	6,850	5,363
Total current assets	224,493	282,780
Property and equipment, net	1,600	1,830
Operating lease right-of-use (ROU) assets	9,131	11,975
Other assets	6,392	1,684
Indefinite-lived intangible asset	29,000	29,000
Goodwill	12,638	12,638
Total assets	**$ 283,254**	**$ 339,907**
LIABILITIES AND STOCKHOLDERS' EQUITY		
Current liabilities		
Accounts payable	$ 4,598	$ 1,731
Accrued clinical expenses	4,444	4,826
Other accrued expenses	11,987	8,286
Deferred revenue - short-term	—	6,411
Operating lease liabilities - short-term	3,404	3,186
Total current liabilities	24,433	24,440
Deferred tax liabilities	2,531	2,531
Deferred revenue - long-term	8,987	30,637
Operating lease liabilities - long-term	6,725	9,082
Total liabilities	**42,676**	**66,690**
Commitments and contingencies		
Stockholders' equity		
Preferred stock, $0.001 par value; 5,000,000 shares authorized; no shares issued or outstanding	—	—
Common stock, $0.001 par value; 100,000,000 shares authorized as of December 31, 2020 and 2019; 34,026,680 and 32,558,307 shares issued and outstanding as of December 31, 2020 and 2019, respectively	34	32
Additional paid-in capital	742,387	712,807
Accumulated other comprehensive loss	(270)	(201)
Accumulated deficit	(501,573)	(439,421)
Total stockholders' equity	240,578	273,217
Total liabilities and stockholders' equity	**$ 283,254**	**$ 339,907**

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,		
	2020	**2019**	**2018**
Collaboration revenue	$ 79,105	$ 15,963	$ 14,804
Operating expenses:			
Research and development	106,823	85,757	72,741
General and administrative	37,058	32,919	34,798
Total operating expenses	143,881	118,676	107,539
Loss from operations	**(64,776)**	**(102,713)**	**(92,735)**
Other income			
Interest and other income	2,624	4,305	3,083
Total other income	2,624	4,305	3,083
Loss before income taxes	**(62,152)**	**(98,408)**	**(89,652)**
Income tax benefit (expense)	—	774	(1,099)
Net loss	**$ (62,152)**	**$ (97,634)**	**$ (90,751)**
Other comprehensive income			
Unrealized gain (loss) on marketable securities, net of tax	(69)	146	45
Comprehensive loss	**$ (62,221)**	**$ (97,488)**	**$ (90,706)**
Net loss per share, basic and diluted	$ (1.75)	$ (3.72)	$ (3.98)
Weighted average common shares outstanding, basic and diluted	35,427,120	26,258,790	22,801,644

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	Accumulated Other Comprehensive	Accumulated	Total Stockholders'
	Shares	Amount	Capital	Loss	Deficit	Equity
Balance as of December 31, 2017	**20,137,974**	**$ 20**	**$ 364,528**	**$ (392)**	**$ (251,036)**	**$ 113,120**
Sale of common stock, net of underwriters' discount and costs	4,600,000	4	155,421	—	—	155,425
Issuance of common stock upon exercise of stock options	735,030	1	3,959	—	—	3,960
Issuance of common stock under Employee Stock Purchase Plan (ESPP)	21,483	—	408	—	—	408
Issuance of shares of common stock for settlement of restricted stock units (RSUs)	938	—	—	—	—	—
Unrealized gain on marketable securities, net of tax	—	—	—	45	—	45
Stock-based compensation	—	—	28,446	—	—	28,446
Net loss	—	—	—	—	(90,751)	(90,751)
Balance as of December 31, 2018	**25,495,425**	**$ 25**	**$ 552,762**	**$ (347)**	**$ (341,787)**	**$ 210,653**
Sale of common stock and pre-funded warrants, net of underwriters' discount and costs	6,287,878	6	134,655	—	—	134,661
Issuance of common stock upon exercise of stock options	585,292	1	4,237	—	—	4,238
Settlement of RSUs for cash	—	—	(4)	—	—	(4)
Issuance of common stock under ESPP	59,370	—	747	—	—	747
Issuance of shares of common stock for settlement of RSUs	130,342	—	—	—	—	—
Unrealized gain on marketable securities, net of tax	—	—	—	146	—	146
Stock-based compensation	—	—	20,410	—	—	20,410
Net loss	—	—	—	—	(97,634)	(97,634)
Balance as of December 31, 2019	**32,558,307**	**$ 32**	**$ 712,807**	**$ (201)**	**$ (439,421)**	**$ 273,217**
Sale of common stock, net of commissions and fees	892,840	1	5,451	—	—	5,452
Issuance of common stock upon exercise of stock options	175,579	1	1,466	—	—	1,467
Issuance of common stock under ESPP	86,812	—	680	—	—	680
Issuance of shares of common stock for settlement of RSUs	313,142	—	—	—	—	—
Unrealized loss on marketable securities	—	—	—	(69)	—	(69)
Stock-based compensation	—	—	21,983	—	—	21,983
Net loss	—	—	—	—	(62,152)	(62,152)
Balance as of December 31, 2020	**34,026,680**	**$ 34**	**$ 742,387**	**$ (270)**	**$ (501,573)**	**$ 240,578**

See Accompanying Notes to the Consolidated Financial Statements

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

	Year Ended December 31,		
	2020	**2019**	**2018**
Cash flows from operating activities			
Net loss	$ (62,152)	$ (97,634)	$ (90,751)
Adjustments to reconcile net loss to net cash used in operating activities:			
Depreciation and amortization	691	494	643
Non-cash IPR&D expense	1,750	—	—
Stock-based compensation	21,853	20,558	28,485
Net accretion and amortization of investments in marketable securities	(13)	(1,735)	(229)
Non-cash rent expense	5,214	4,454	—
Deferred income tax (benefit) expense	—	(774)	1,099
Loss on disposal of fixed assets	9	102	—
Other	—	(5)	—
Changes in operating assets and liabilities:			
Accounts receivable from collaborations	2,144	(944)	(156)
Prepaid expenses and other current assets	(1,487)	(3,685)	(1,094)
Other assets	(4,708)	1,664	(3,008)
Accounts payable	2,867	(1,962)	1,569
Accrued clinical expenses	(382)	1,265	3,119
Other accrued expenses	3,831	2,016	382
Deferred revenue	(28,061)	(3,612)	(5,125)
Deferred rent	—	—	108
Operating lease liabilities	(4,513)	(4,269)	—
Net cash used in operating activities	(62,957)	(84,067)	(64,958)
Cash flows from investing activities			
Purchases of property and equipment	(470)	(1,554)	(340)
Purchase of IPR&D	(1,750)	—	—
Purchases of marketable securities	(193,188)	(281,334)	(183,941)
Proceeds from maturities of marketable securities	221,617	203,911	48,884
Proceeds from sale of marketable securities	41,861	28,659	—
Net cash provided by (used in) investing activities	68,070	(50,318)	(135,397)
Cash flows from financing activities			
Proceeds from common stock and pre-funded warrants sold, net of underwriters' discount, commissions and costs	5,452	134,661	155,425
Proceeds from the issuance of common stock under ESPP	680	747	408
Proceeds from the exercise of stock options	1,467	4,238	3,960
Net cash provided by financing activities	7,599	139,646	159,793
Net increase (decrease) in cash and cash equivalents	12,712	5,261	(40,562)
Cash and cash equivalents at the beginning of the period	46,732	41,471	82,033
Cash and cash equivalents at the end of the period	**$ 59,444**	**$ 46,732**	**$ 41,471**
Supplemental non-cash investing and financing activities			
Operating lease liabilities arising from obtaining right-of-use assets	$ 1,302	$ 15,261	$ —

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 clinical-stage biotechnology company advancing a novel class of oral therapeutic candidates for the treatment of hepatitis B virus (HBV) infection. The Company operates in one segment and is headquartered in South San Francisco, California with operations in California, Connecticut and China.

The Company's research and development programs are pursuing multiple drug candidates that inhibit the HBV replication cycle and block the generation of covalently closed circular DNA (cccDNA), with the aim of discovering and developing finite and curative therapies for patients with HBV. Assembly has discovered multiple novel core inhibitors, which are small molecules that directly target and allosterically modify the HBV core (HBc) protein.

In December 2020, the Company and its Board of Directors approved a plan to wind down its Microbiome program in order to prioritize and focus its resources entirely on discovering and developing finite and curative therapies for HBV. The Microbiome program had been developing a novel class of oral live microbial biotherapeutics candidates designed to treat disorders associated with the microbiome.

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 (see Note 7 for recent sales of common stock). The Company cannot assure such funding will be available on reasonable terms, if at all. Market volatility resulting from the novel coronavirus disease (COVID-19) pandemic or other factors could also adversely impact the Company's ability to access capital when and as needed.

If the Company is unable to generate enough revenue from its collaborations, secure additional sources of funding 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 the accounting principles generally accepted in the United States of America (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 for the cost-based input of revenue recognition and standalone selling price estimates for allocation of transaction price to performance obligations revenue recognition, estimates of costs incurred but not yet invoiced for clinical trial accruals, recoverability and useful lives of our long-lived assets, the estimated fair value of our indefinite-lived intangible assets, the estimated fair value of our reporting unit for purposes of evaluating goodwill impairment, provisions for income taxes, amounts receivable under collaboration agreements, measurement of operating lease liabilities, and the fair value of stock options, stock appreciation rights, and RSUs granted to employees, directors, and consultants.

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

In March 2020, the World Health Organization declared the COVID-19 outbreak a pandemic. To date, the Company's operations have not been significantly impacted by the COVID-19 pandemic. However, the Company cannot at this time predict the specific extent, duration, or full impact the COVID-19 pandemic will have on its business, operations, strategy, prospects and financial condition and results. The impact of the COVID-19 pandemic on the Company's financial performance will depend on future developments, including the duration and spread of the outbreak and related governmental advisories and restrictions. These developments and the impact of the COVID-19 pandemic on the financial markets and the overall economy are highly uncertain. If the financial markets and/or the overall economy are impacted for an extended period, the Company's results may be adversely affected.

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 and at December 31, 2020 and 2019, 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 are classified as short-term available-for-sale securities and are reported as a component of current assets.

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 our investments in marketable securities.

Goodwill and Indefinite-Lived Intangible Asset

Goodwill and indefinite-lived intangible assets are reviewed for impairment at least annually in the fourth quarter, and more frequently if events or other changes in circumstances indicate that the carrying amount of the assets may not be recoverable. Impairment of goodwill and indefinite-lived intangibles is determined to exist when the fair value is less than the carrying value of the net assets being tested.

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 is evaluated for impairment on an annual basis as of October 1, and more frequently if indicators are present or changes in circumstances suggest that impairment may exist. In performing each annual impairment assessment and any interim impairment assessment, the Company determines if it should qualitatively assess whether it is more likely than not that the fair value of goodwill is less than its carrying amount (the qualitative impairment test). If the Company concludes it is more likely than not that the fair value of the reporting unit is less than its carrying amount, or elect not to use the qualitative impairment test, a quantitative impairment test is performed The Company annual or interim quantitative impairment testing is performed by comparing the estimated fair value of the reporting unit to its carrying value. An impairment charge is recognized for the amount by which the carrying amount exceeds the reporting unit's fair value, not to exceed the carrying value of goodwill.

As of October 1, 2020 the Company has determined through its quantitative impairment test that the fair value of its goodwill significantly exceeded the carrying value of its single reporting unit and concluded that goodwill was not impaired. In November 2020, after the Company's public announcement that it became clear that patients who stopped therapy in Study 211 had not achieved meaningful sustained virologic response rates most of the patients had relapsed, the Company's stock price declined significantly. Due to a sustained decline in the Company's stock price during the remainder of the fourth quarter of 2020, the Company determined these factors were an indication of a triggering event of impairment and an interim goodwill impairment test was performed as of December 31, 2020. However, the interim quantitative impairment test still determined the fair value, when considering a control premium based on a range of recent acquisitions of entities similar to the Company which were made on a non-minority basis, exceeded the carrying value of its single reporting unit, and concluded that goodwill was still not impaired. The Company has not recognized any goodwill impairment in any of the periods presented.

Indefinite-Lived Intangible Asset

The Company's indefinite-lived intangible asset consists of IPR&D acquired in a business combination that are used in research and development activities but have not yet reached technological feasibility, regardless of whether they have alternative future use. The primary basis for determining the technological feasibility or completion of these projects is obtaining regulatory approval to market the underlying products in an applicable geographic region. The Company classifies IPR&D acquired in a business combination as an indefinite-lived intangible asset until the completion or abandonment of the associated research and development efforts. Upon completion of the associated research and development efforts, the Company performed a final test for impairment and will determine the useful life of the technology and 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 are not amortized, but instead are reviewed for impairment at least annually, or more frequently if events occur or circumstances change that would indicate the carrying amount may be impaired. In performing each annual impairment assessment and any interim impairment assessment, the Company determines if it should qualitatively assess whether it is more likely than not that the fair value of its IPR&D asset is less than its carrying amount (the qualitative impairment test). If the Company concludes that is the case, or elect not to use qualitative impairment test, the Company 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).

When performing the quantitative impairment assessment, the Company uses 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 includes 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 are based on estimates of the sales price of the drug, the size of the patient population and cure rate, our competitive position in the marketplace, and appropriate discount and tax rates. Any impairment to be recorded is 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 its consolidated balance sheet.

In performing the qualitative impairment test, the Company considers the results of the most recent quantitative impairment test and identifies the most relevant drivers of the fair value for the IPR&D asset. The most relevant drivers of fair value identified are consistent with the assumptions used in the quantitative estimate of the IPR&D asset discussed below. Using these drivers of fair value, the Company identifies events and circumstances that may have 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 weighs these factors to determine and conclude if it is not more likely than not that the IPR&D asset is impaired. If it is more likely than not that the IPR&D asset is impaired, the Company proceeds with quantitatively determining the fair value of the IPR&D asset.

For the Company's 2020 impairment test, the Company performed a qualitative test and concluded it was more-likely-than-not that the fair value of its IPR&D asset exceeded its carrying value and no further testing was required. This was based on a decrease in the probability of success based on the impact of the Study 211 and dual combination VBR and NrtI therapy's ability to serve as a finite and curative therapy for chronic HBV infection offset by an increase in the probability of success of 2158 and 3733 based on their advancement into Phase 2 and Phase 1 trials during 2020, respectively and the significance of the future net cash flows from potential drug sales for a finite and curative therapy for chronic HBV infection as primarily driven by the number of patients who will be diagnosed and treated and the Company's competitive position in the marketplace. The Company did not recognize any IPR&D impairment in any of the periods presented.

Leases

All of the Company's leases are operating leases for facilities and equipment. Prior to January 1, 2019, the Company recognized related rent expense on a straight-line basis over the term of the lease. Incentives granted under the Company's facilities lease, including allowances for leasehold improvements and rent holidays, were recognized as reductions to rental expense on a straight-line basis over the term of the lease. Deferred rent consisted of the difference between cash payments and the rent expense recognized.

Subsequent to the adoption of the new leasing standard on January 1, 2019, 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 right-of-use assets, operating lease liabilities - short-term, and operating lease liabilities - long-term in the Company's consolidated balance sheets. Operating lease right-of-use 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 right-of-use 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. In conjunction with the decision to wind down the Microbiome program in December 2020, the Company evaluated its ROU assets and property and equipment used in the Microbiome program for impairment. The Company determined the carrying value was no longer recoverable and, based on a fair value of the assets determined from market quotes, recorded an impairment loss of $0.7 million included in research and development expenses. The Company did not recognize any impairment on its long-lived assets in 2019 or 2018.

Property and Equipment, Net

Property and equipment are stated at cost and consist of lab and office equipment, leasehold improvements and computer hardware and software. 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 us 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 that 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 that 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, 2020			
	Level 1	Level 2	Level 3	Estimated Fair Value
Cash equivalents				
Money market funds	$ 47,553	$ —	$ —	$ 47,553
U.S. and foreign commercial paper	—	6,498	—	6,498
Total cash equivalents	47,553	6,498	—	54,051
Short-term investments				
U.S. and foreign corporate debt securities	—	16,939	—	16,939
Asset-backed securities	—	12,675	—	12,675
U.S. treasury securities	—	23,999	—	23,999
U.S. and foreign commercial paper	—	103,356	—	103,356
Total short-term investments	—	156,969	—	156,969
Total assets measured at fair value	$ 47,553	$ 163,467	$ —	$ 211,020

	December 31, 2019			
	Level 1	Level 2	Level 3	Estimated Fair Value
Cash equivalents				
Money market fund	$ 33,095	$ —	$ —	$ 33,095
U.S. and foreign corporate debt securities	—	4,999	—	4,999
U.S. and foreign commercial paper	—	4,484	—	4,484
Total cash equivalents	33,095	9,483	—	42,578
Short-term investments				
U.S. and foreign corporate debt securities	—	72,486	—	72,486
Asset-backed securities	—	34,025	—	34,025
U.S. treasury securities	—	44,714	—	44,714
U.S. and foreign commercial paper	—	76,086	—	76,086
Total short-term investments	—	227,311	—	227,311
Total assets measured at fair value	$ 33,095	$ 236,794	$ —	$ 269,889

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.

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 our investments in marketable securities.

Revenue Recognition and Accounts Receivable from Collaborations

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 standalone selling price of each performance obligation identified in the contract. The Company then allocates the total transaction price to each performance obligation based on the estimated standalone selling prices 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.

Research and Development Service Payments

Under the Research, Development, Collaboration and License Agreement (Allergan Agreement) with Allergan Pharmaceuticals International Limited (Allergan), the Company was reimbursed at a certain percentage for performing research and development services based on hours worked by the Company's employees, at a fixed contractual rate per hour, and third-party pass-through costs the Company incurred on a quarterly basis. Research and development service payments were included in the transaction price in the reporting period the Company concluded it was probable that recording revenue in the period would not result in a significant reversal in amounts recognized in future periods. Accounts receivable were recorded when the right to the research and development service payment consideration became unconditional. The Company recorded the full reimbursed portion of these expenses as collaboration revenue associated with the Allergan Agreement in its consolidated statements of operations as the Company consider performing research and development services to be a part of its ongoing and central operations.

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 each 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, 2020 and 2019, all accounts receivable are deemed collectible.

Stock-Based Compensation

The Company measures stock-based compensation to employees, consultants, and Board members 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. 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. 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 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.

Prior to January 1, 2019, the Company remeasured the fair value of the non-employee awards at each reporting period prior to vesting and finally at the vesting date of the award. Changes in the estimated fair value of these non-employee awards were recognized as compensation expense in the period of change. After January 1, 2019, the Company recognizes non-employee compensation costs over the requisite service period based on a measurement of fair value for each stock award.

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 Collaboration Agreement. 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. Assets acquired as part of an asset acquisition that are used in research and development or are IPR&D are immediately expensed as research and development unless there is an alternative future use in other research and development projects.

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 (CROs) 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 to be 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 planned 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.

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.

Variable Interest Entities

The Company reviews agreements it enters into with third party entities, pursuant to which we 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 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. As of December 31, 2020, the Company did not consolidate any entities it had determined to be VIEs.

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 that 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 March 2020, the Families First Coronavirus Response Act (FFCR Act) and the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) were each enacted in response to the COVID-19 pandemic. The FFCR Act and the CARES Act contain numerous income tax provisions relating to refundable payroll tax credits, deferment of employer side social security payments, net operating loss carryback periods, alternative minimum tax credit refunds, modifications to the net interest deduction limitations and technical corrections to tax depreciation methods for qualified improvement property.

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.

In December 2020, the Consolidated Appropriations Act, 2021 (CAA) was signed into law. The CAA included additional funding through tax credits as part of its economic package for 2021.

The FFCR Act, CARES Act, A.B. 85 did and CAA not have a material impact on the Company's consolidated financial statements; however, the Company continues to examine the impacts the FFCR Act, CARES Act, A.B. 85 and CAA may have on its business, results of operations, financial condition and liquidity.

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.

In December 2019, the Company sold 6,287,878 shares of common stock as well as pre-funded warrants to purchase up to 2,424,242 shares of common stock (see Note 7). The pre-funded warrants are exercisable for shares of common stock at a price of $0.001 per share. The shares of common stock into which the pre-funded warrants may be exercised are considered outstanding for the purposes of computing earnings per share because the shares may be issued for little or no consideration, they are fully vested, and are exercisable after the original issuance date.

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

	Year Ended December 31,		
	2020	**2019**	**2018**
Warrants to purchase common stock	—	15,296	15,296
Options to purchase common stock	6,696,592	5,613,353	4,637,145
Common stock subject to purchase under our ESPP	44,223	11,342	21,483
Unvested RSUs	746,868	630,384	568,005
Total	7,487,683	6,270,375	5,241,929

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.

Adoption of Recent Accounting Pronouncements

In January 2017, the Financial Accounting Standards Board (FASB) issued ASU 2017-04, *Intangibles-Goodwill and Other (Topic 350): Simplifying the Test for Goodwill Impairment* (ASU 2017-04), which simplifies how an entity is required to test goodwill for impairment by eliminating Step 2 from the goodwill impairment test. Step 2 measures a goodwill impairment loss by comparing the implied fair value of a reporting unit's goodwill with the carrying amount of that goodwill. Under the amendments in ASU 2017-04, an entity should recognize an impairment charge for the amount by which the carrying amount of a reporting unit exceeds its fair value; however, the loss recognized should not exceed the total amount of goodwill allocated to that reporting unit. The updated accounting standard requires a prospective adoption. 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* (ASU 2019-10), 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 for goodwill impairment tests performed on testing dates after January 1, 2017. The Company early adopted ASU 2017-04 effective January 1, 2020. The adoption of this standard had no material impact on the Company's consolidated financial statements.

On January 1, 2020, the Company adopted ASU 2018-13, *Fair Value Measurement (Topic 820): Disclosure Framework - Changes to the Disclosure Requirements for Fair Value Measurement,* which makes a number of changes meant to add, modify or remove certain disclosure requirements associated with the movement amongst or hierarchy associated with Level 1, Level 2 and Level 3 fair value measurements. The adoption of this standard had no material impact on the Company's consolidated financial statements and related disclosures.

On January 1, 2020, the Company adopted ASU 2018-18, *Collaborative Arrangements (Topic 808): Clarifying the Interaction between Topic 808 and Topic 606*, which clarifies that certain transactions between collaborative arrangement participants should be accounted for as revenue under Topic 606 when the collaborative arrangement participant is a customer in the context of a unit of account. In those situations, all the guidance in Topic 606 should be applied, including recognition, measurement, presentation, and disclosure requirements. The standard adds unit-of-account guidance in Topic 808 to align with the guidance in Topic 606 (that is, a distinct good or service) when an entity is assessing whether the collaborative arrangement or a part of the arrangement is within the scope of Topic 606 and requires that in a transaction with a collaborative arrangement participant that is not directly related to sales to third parties, presenting the transaction together with revenue recognized under Topic 606 is precluded if the collaborative arrangement participant is not a customer. Amendments in the standard should be applied retrospectively to the date of initial application of Topic 606, but entities may elect to apply the amendments in Topic 808 retrospectively either to all contracts or only to contracts that are not completed at the date of initial application of Topic 606, and should disclose the election. An entity may also elect to apply the practical expedient for contract modifications that is permitted for entities using the modified retrospective transition method in Topic

606. The adoption of this standard had no impact on the Company's consolidated financial statements and related disclosures.

In December 2019, the FASB issued ASU No. 2019-12, *Simplifying the Accounting for Income Taxes* (ASU 2019-12), which eliminates certain exceptions to the guidance in *Income Taxes (Topic 740)* related to the approach for intraperiod tax allocation, the methodology for calculating income taxes in an interim period and the recognition of deferred tax liabilities for outside basis differences. The new accounting standard also simplifies aspects of the accounting for franchise taxes and enacted changes in tax laws or rates and clarifies the accounting for transactions that result in a step-up in the tax basis of goodwill. The standard is effective for fiscal years beginning after December 15, 2020 and interim periods within those fiscal years. Early adoption is permitted in an interim or annual period. Entities that elect to early adopt the amendments in an interim period should reflect any adjustments as of the beginning of the annual period that includes that interim period. Additionally, entities that elect early adoption must adopt all the amendments in the same period. Entities will apply the accounting standard prospectively, except for certain amendments. The Company early adopted ASU 2019-12 effective January 1, 2020. The adoption of this standard did not have a material impact on the Company's consolidated financial statements and related disclosures.

Accounting Pronouncements to Be Adopted

In June 2016, 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 also 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 accounting standard 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* (ASU 2019-10), 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 is currently evaluating the timing and impact of adopting this new accounting standard on its consolidated financial statements and related disclosures.

In August 2020, the FASB issued ASU 2020-06, *Debt—Debt with Conversion and Other Options (Subtopic 470-20) and Derivatives and Hedging—Contracts in Entity's Own Equity (Subtopic 815-40): Accounting for Convertible Instruments and Contracts in an Entity's Own Equity* (ASU 2020-06), which simplifies the accounting for certain financial instruments with characteristics of liabilities and equity, including convertible instruments and contracts on an entity's own equity. Specifically, ASU 2020-06 simplifies accounting for convertible instruments by removing major separation models in ASC 470-20 that require separate accounting for embedded conversion features. The ASU also removes certain settlement conditions in ASC 815-40 that are required for equity contracts to qualify for the derivative scope exception, which will permit more equity contracts to qualify for the scope exception and simplifies the diluted EPS calculation in certain areas. The ASU is effective for interim and annual periods beginning after December 15, 2021, with early adoption permitted after December 15, 2020. Adoption of the ASU can either be on a modified retrospective or full retrospective basis. The Company is currently evaluating the impacts of ASU 2020-06 on its consolidated financial statements and related disclosures.

In October 2020, the FASB issued ASU 2020-10, Codification Improvements – Disclosures. This ASU improves consistency by amending the codification to include all disclosure guidance in the appropriate disclosure sections and clarifies application of various provisions in the Codification by amending and adding new headings, cross referencing to other accounting standards, and refining or correcting termination. This ASU is effective for fiscal years beginning after December 15, 2020. The adoption of the ASU will not impact the Company's consolidated financial statements or related disclosures.

Note 3 - Investments in Marketable Securities

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

	December 31, 2020			
	Amortized Cost	Gross Unrealized Gain [1]	Gross Unrealized Loss [1]	Estimated Fair Value
Cash equivalents				
Money market funds	$ 47,553	$ —	$ —	$ 47,553
U.S. and foreign commercial paper	6,498	—	—	6,498
Total cash equivalents	54,051	—	—	54,051
Short-term investments				
U.S. and foreign corporate debt securities	16,939	3	(3)	16,939
Asset-backed securities	12,674	2	(1)	12,675
U.S. treasury securities	23,997	2	—	23,999
U.S. and foreign commercial paper	103,356	—	—	103,356
Total short-term investments	156,966	7	(4)	156,969
Total cash equivalents and investments	$ 211,017	$ 7	$ (4)	$ 211,020

	December 31, 2019			
	Amortized Cost	Gross Unrealized Gain [1]	Gross Unrealized Loss [1]	Estimated Fair Value
Cash equivalents				
Money market funds	$ 33,095	$ —	$ —	$ 33,095
U.S. and foreign corporate debt securities	5,000	—	(1)	4,999
U.S. and foreign commercial paper	4,484	—	—	4,484
Total cash equivalents	42,579	—	(1)	42,578
Short-term investments				
U.S. and foreign corporate debt securities	72,452	38	(4)	72,486
Asset-backed securities	34,008	17	—	34,025
U.S. treasury securities	44,692	24	(2)	44,714
U.S. and foreign commercial paper	76,086	—	—	76,086
Total short-term investments	227,238	79	(6)	227,311
Total cash equivalents and investments	$ 269,817	$ 79	$ (7)	$ 269,889

[1] Gross unrealized gain (loss) is pre-tax.

As of December 31, 2020, the contractual term to maturity of short-term marketable securities held by the Company is less than one year. There were no long-term marketable securities held by the Company as of December 31, 2020.

Realized gains and losses for the years ended December 31, 2020, 2019 and 2018 were not significant. None of the Company's investments have been in a continuous unrealized loss position for more than 12 months as of December 31, 2020.

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

Note 4 - Property and Equipment, Net

Property and equipment consist of the following (in thousands):

	As of December 31,	
	2020	2019
Lab equipment	$ 247	$ 247
Office equipment	699	699
Leasehold improvement	2,490	2,084
Total property and equipment	3,436	3,030
Less: Accumulated depreciation	(1,836)	(1,200)
Property and equipment, net	$ 1,600	$ 1,830

Depreciation expense for the years ended December 31, 2020, 2019 and 2018 was $0.7 million, $0.5 million, and $0.6 million, respectively, and was recorded in both research and development expense and general and administrative expense in the consolidated statements of operations and comprehensive loss. Primarily all of property and equipment is located in the U.S.

Note 5 – Other Accrued Expenses

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

	As of December 31,	
	2020	2019
Other accrued expenses:		
Accrued compensation	$ 7,016	$ 5,312
Accrued restructuring charges	4,164	2,094
Accrued professional fees and other	807	880
Total other accrued expenses	$ 11,987	$ 8,286

Note 6 – Restructurings

2019 Restructuring

In November 2019, the Company's Board of Directors approved the relocation of the Company corporate headquarters to South San Francisco, California which became effective January 1, 2020. The Company accrued restructuring charges of $2.1 million in 2019 related to one-time termination severance payments and other employee-related costs associated with the relocation plan. This represents the total amount expected to be incurred in connection with the relocation.

2020 Restructuring

In December 2020, the Company and its Board of Directors determined that it was in the Company's best interest to wind down its Microbiome program, enabling the Company to prioritize resources and focus on the advancement of its pipeline of novel core inhibitors for chronic HBV infection. The Company expects to complete the wind-down of the Microbiome program in early 2021.

The following table summarizes the Company's estimates of costs incurred and expected to be incurred (in thousands):

	Total Restructuring Cost	Employee Severance and Related Benefits	Asset Impairment and Other Costs
Total estimated restructuring costs to be incurred	$ 8,040	$ 6,461	$ 1,579
Restructuring costs incurred during the period:			
Total restructuring costs incurred for the year ended December 31, 2019	2,094	2,094	—
Total restructuring costs incurred for the year ended December 31, 2020	5,684	4,105	1,579
Cumulative restructuring costs incurred through December 31, 2020	$ 7,778	$ 6,199	$ 1,579

The following table presents the activity in the accrued restructuring charges during the period, all of which are related to employee severance and related benefits (in thousands):

Accrued balance as of January 1, 2019	$ —
Costs incurred	2,094
Accrued balance as of December 31, 2019	$ 2,094
Costs incurred	3,843
Reductions for cash payments	(1,773)
Accrued balance as of December 31, 2020	$ 4,164

The Company also recognized $0.3 million of accelerated vesting for stock-based compensation for employees subject to the restructuring activities during 2020.

The Company expects the accrued restructuring liability to be fully paid in 2021.

The following table presents where the restructuring charges were recognized (in thousands):

	Year Ended December 31,	
	2020	2019
Research and development	$ 5,486	$ 433
General and administrative	198	1,661
Total	$ 5,684	$ 2,094

Note 7 - Stockholders' Equity

The Company is authorized to issue 5,000,000 shares of preferred stock as of December 31, 2020 and 2019, respectively. As of December 31, 2020 and 2019, no shares of preferred stock were issued and outstanding. The Company is authorized to issue 100,000,000 shares of common stock as of December 31, 2020 and 2019, respectively.

Sale of Common Stock and Pre-Funded Warrants

In December 2017, the Company filed a registration statement on Form S-3 with the SEC, File No. 333-222366, that became effective January 10, 2018 (the 2018 Registration Statement). The 2018 Registration Statement gave the Company the ability to sell any combination of the securities described in the 2018 Registration Statement in one or more offerings up to an aggregate offering price of $250.0 million. In connection with the filing of the 2018 Registration Statement, the Company entered into a sales agreement that gave the Company the ability to sell shares of its common stock having an aggregate offering price of up to $75.0 million through "at the market offerings" (the 2017 ATM). The 2017 ATM was terminated effective September 6, 2020, and no shares were sold under the 2017 ATM prior to the termination.

In July 2018, the Company sold to various investors an aggregate of 4,600,000 shares of common stock in a public offering at $36.00 per share, which included the exercise in full by the underwriters of their option to purchase 600,000 additional shares of common stock. The Company received aggregate net proceeds of $155.4 million from the offering and the option exercise, after deducting underwriting discounts and commissions and offering expenses payable by the Company.

In December 2019, the Company sold to various investors an aggregate of 6,287,878 shares of common stock at a public offering price of $16.50 per share, which included the exercise in full by the underwriters of their option to purchase 1,136,363 shares of common stock, and pre-funded warrants to purchase 2,424,242 shares of common stock at a public offering price of $16.499. The Company received aggregate net proceeds of $134.7 million from the offering and the option exercise, after deducting underwriting discounts and commissions and offering expenses payable by the Company. The pre-funded warrants became immediately exercisable upon issuance at an exercise price of $0.001 per share, but under their terms, the outstanding pre-funded warrants to purchase shares of the Company's common stock generally may not be exercised if the holder's ownership of the Company's common stock would exceed 19.99% following such exercise. The exercise price and number of shares of common stock issuable upon the exercise of the pre-funded warrants (Warrant Shares) are subject to adjustment in the event of any stock dividends and splits, reverse stock split, recapitalization, reorganization or similar transaction, as described in the pre-funded warrant agreements. Under certain circumstances, the pre-funded warrants may be exercisable on a "cashless" basis. Both the pre-funded warrants and the Warrant Shares are registered securities.

The pre-funded warrants were classified as a component of permanent stockholders' equity within additional paid-in-capital and were recorded at the issuance date using a relative fair value allocation method. The pre-funded warrants are equity classified because they are freestanding financial instruments that are legally detachable and separately exercisable from the equity instruments, are immediately exercisable, do not embody an obligation for the Company to repurchase its shares, permit the holders to receive a fixed number of common shares upon exercise, are indexed to the Company's common stock and meet the equity classification criteria. In addition, such pre-funded warrants do not provide any guarantee of value or return. The Company valued the pre-funded warrants at issuance, concluding their sales price approximated their fair value, and allocated net proceeds from the sale proportionately to the common stock and pre-funded warrants of which $37.5 million allocated to the pre-funded warrants and recorded as a component of additional paid-in-capital.

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, 2020, the Company issued and sold 892,840 shares of common stock under the 2020 Registration Statement, for which the Company received net proceeds of $5.5 million, after deducting commissions, fees and expenses.

The Company carried forward registration fees paid with respect to $21.4 million of securities that remained available under the 2018 Registration Statement. As such, as of the effectiveness of the 2020 Registration Statement, the 2018 Registration Statement was deemed terminated.

Common Stock Warrants

As of December 31, 2020, the following warrants to purchase shares of the Company's common stock were issued and outstanding:

Issue date	Expiration date	Exercise Price per Share	December 31, 2020	December 31, 2019
September 10, 2010 ...	September 10, 2020	$ 30.000	—	15,296
December 16, 2019	None	$ 0.001	2,424,242	2,424,242
			2,424,242	2,439,538

There were no warrants exercised during the years ended December 31, 2020, 2019 and 2018. During the year ended December 31, 2020, 15,296 warrants to purchase common stock expired unexercised. During the year ended December 31, 2018, 1,613 warrants to purchase common stock expired unexercised.

Note 8 - Stock-Based Compensation

Equity Incentive Plans

In May 2018, the Company's stockholders approved (1) the Assembly Biosciences, Inc. 2018 Stock Incentive Plan (the 2018 Plan) pursuant to which the Company reserved 1,900,000 shares of its common stock for issuance in connection with equity incentive awards and (2) the Assembly Biosciences, Inc. Employee Stock Purchase Plan (the 2018 ESPP) pursuant to which the Company reserved 400,000 shares of its common stock for issuance in connection with purchases by employees pursuant to this plan.

In May 2019, the Company's stockholders approved an amendment to the 2018 Plan that increased the aggregate shares of common stock reserved under the 2018 Plan to 3,000,000.

In June 2020, 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 4,600,000.

As of December 31, 2020, 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, 2020, the Company also had awards outstanding under the Assembly Biosciences, Inc. 2017 Inducement Award Plan (the 2017 Plan), the 2019 Inducement Award Plan (the 2019 Plan) and the Assembly Biosciences, Inc. 2020 Inducement Award Plan (the 2020 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 2020:

	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, 2019	5,613,353	$ 15.90		
Granted	1,649,340	16.07		
Exercised	(175,579)	9.75		
Forfeited	(390,522)	22.81		
Outstanding as of December 31, 2020	6,696,592	$ 15.70	6.9	$ 1,856
Exercisable as of December 31, 2020	3,926,732	$ 14.70	5.5	$ 1,813

The weighted-average grant-date fair value of options granted was $10.64, $10.55 and $30.84 during the years ended December 31, 2020, 2019 and 2018, respectively. The total intrinsic value of options exercised in 2020, 2019 and 2018 was $2.0 million, $5.0 million and $31.1 million, respectively.

RSUs

The following table summarizes RSU activity and related information for 2020:

	Number of RSU's		Weighted Average Fair Value Per RSU at Grant Price
Nonvested as of December 31, 2019	758,718		$ 25.47
Granted	536,164		16.21
Vested	(297,133)		23.65
Forfeited	(110,881)		26.46
Nonvested as of December 31, 2020	886,868	(1)	$ 20.36

(1) Includes 140,000 RSUs that have vested but are subject to deferred settlement, which have a weighted average remaining contractual term of 2.2 years.

The total fair value of RSUs vested and settled during 2020, 2019 and 2018 was $7.8 million, $5.7 million, and $5.3 million, respectively. The total intrinsic value of RSUs vested and settled during 2020 and 2019 was $4.4 million and $2.9 million, respectively. The total intrinsic value of RSUs vested and settled during 2018 was nominal.

As of December 31, 2020, RSUs outstanding include 100,000 RSUs granted in September 2019 to the Company's chief executive officer with performance-based conditions. The 100,000 awards with an aggregate fair value of $1.2 million vest upon performance conditions not yet deemed probable and accordingly no stock-based compensation expense has been recognized as of December 31, 2020. In July 2020, the performance condition for 45,000 RSUs granted in December 2017 to a former executive officer was met associated with the execution of an HBV business development transaction. The Company recognized $0.7 million as a cumulative catch-up adjustment of stock-based compensation expense for this award for the year ended December 31, 2020. In the second quarter of 2019, 100,000 RSUs granted to a former officer were forfeited due to his departure. These RSUs had a grant date fair value of $2.4 million and were vesting over time but would have accelerated upon the achievement of certain performance-based conditions. The Company reversed the previously recognized expense of $0.5 million related to these forfeited awards upon the departure of the former officer in 2019.

Employee Stock Purchase Plan

The 2018 ESPP provides for the purchase by employees of up to an aggregate of 400,000 shares of the Company's common stock at a discount to the market price. Subject to the annual statutory limits and the 2018 ESPP's limit of 1,000 shares of common stock per offering, an eligible employee may participate through payroll deductions of up to 15% of such employee's compensation for each pay period

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 November 2018, employees purchased 21,483 shares of common stock under the 2018 ESPP. In May and November 2019, employees purchased 36,804 and 22,566 shares of common stock, respectively, under the 2018 ESPP. In May and November 2020, employees purchased 42,266 and 44,546 shares of common stock, respectively, under the 2018 ESPP. As of December 31, 2020, 232,335 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 $0.5 million, $0.4 million and $0.2 million for the years December 31, 2020, 2019 and 2018, respectively.

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,		
	2020	2019	2018
Exercise price	$5.62 - $23.30	$9.31 - $23.04	$23.78 - $57.53
Expected volatility	66.4% - 92.3%	66.5% - 83.2%	75.6% - 86.1%
Risk-free interest rate	0.26% - 1.44%	1.36% - 2.65%	2.56% - 3.04%
Expected term (years)	5.5 - 7.5	5.5 - 7.5	5.5 - 7.0
Expected dividend yield	0%	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, supplemented as necessary with historical volatility of the common stock of several peer companies with characteristics similar to those of the Company.

The fair value of ESPP purchase 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 periods presented (in thousands):

	Year Ended December 31,		
	2020	2019	2018
Research and development	$ 11,380	$ 11,376	$ 11,820
General and administrative	10,473 (1)	9,182 (2)	16,665
Total stock-based compensation expense	**$ 21,853**	**$ 20,558**	**$ 28,485**

(1) Includes the reversal of previously recognized expense of $1.7 million related to forfeited awards resulting from the departure of one of our former executive officers during the year.

(2) Includes the reversal of previously recognized expense of $3.6 million related to forfeited awards resulting from the departure of one of our former executive officers during the year.

As of December 31, 2020, there was $20.4 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 1.8 years.

Note 9 - Collaboration Agreements

Allergan Agreement

In January 2017, the Company and Allergan entered into the Allergan Agreement to develop and commercialize select microbiome gastrointestinal disease therapies. Pursuant to the Allergan Agreement, the Company granted Allergan an exclusive worldwide license to certain of its intellectual property, including its intellectual property arising under the Allergan Agreement, to develop and commercialize licensed compounds for ulcerative colitis (UC), Crohn's disease, and two compounds for irritable bowel syndrome (IBS). Allergan and the Company also agreed to collaborate on research and development activities with respect to the licensed compounds in accordance with a mutually agreed upon research and development plan. Per the terms of the Allergan Agreement, Allergan could select backups and additional target indications to add to the licenses granted for additional consideration and also had the ability to enter into a contract manufacturing agreement with the Company for compound supply at cost plus an agreed upon margin. In addition, the Company participated on a Joint Development Committee (JDC) and Joint Patent Committee (JPC). Allergan had the right to terminate the Allergan Agreement at any time upon advance written notice.

In June 2020, following its acquisition of Allergan, AbbVie Inc. (AbbVie), on behalf of Allergan, gave written notice of termination of the Allergan Agreement effective 120 days following the delivery of notice, on October 10, 2020. Upon termination, the licenses granted by the Company and its know-how reverted to the Company. Under the terms of the Allergan Agreement, AbbVie was obligated to continue to reimburse the Company for certain research and development costs through October 10, 2020. Upon effectiveness of the termination, such reimbursements ceased. Due to the delivery of the termination notice, the Company determined there were no further enforceable rights and obligations under the Allergan Agreement beyond June 2020 and the remaining $36.0 million of deferred revenue was recognized in 2020.

Allergan paid the Company an upfront non-refundable payment of $50.0 million which was received in 2017. Additionally, the Company was eligible to receive variable consideration in the form of research and development cost reimbursements, up to $631.0 million related to seven development milestones and up to $2.14 billion related to 12 commercial development and sales milestones in connection with the successful development and commercialization of licensed compounds. In addition, the Company was eligible to receive tiered royalties at rates ranging from the mid-single digits to the mid-teens based on net sales.

Allergan and the Company agreed to share research and development costs up to an aggregate of $75.0 million through proof-of-concept (POC) studies on a ⅔, ⅓ basis, respectively, and Allergan agreed to assume all post-POC development costs. In the event any pre-POC development costs would have exceeded $75.0 million in the aggregate, the Company may have elected either (a) to fund ⅓ of such costs in excess of $75.0 million or (b) to allow Allergan to deduct from future development milestone payments ⅓ of the development costs funded by Allergan in excess of $75.0 million plus a premium of 25%. The Company had an option to co-promote the licensed programs in the U.S. and China, subject to certain conditions set forth in the Allergan Agreement.

The Company concluded that Allegan was a customer, and the contract was not subject to accounting literature on collaborative arrangements. This is because the Company granted to Allergan licenses to its intellectual property and agreed to perform research and development services, all of which are outputs of the Company's ongoing activities, in exchange for consideration. The Company identified the following material promises under the Allergan Agreement: (1) grant of a licenses to intellectual property for the four initial indications, inclusive of the related technology know-how (Licenses) and (2) the obligation to perform research development services through POC (Development Services). The Company's participation on the JDC and JPC were considered to be immaterial in the context of the contract. The Company's co-promotion option was not considered to be a performance obligation. Allergan's selection of backups or additional target indications to add to the licenses granted for additional consideration and ability to enter into a contract manufacturing agreement with the Company for compound supply at cost plus an agreed upon margin were not considered to be performance obligations as the Company concluded the options were not offered at a discount that exceeds discounts available to other customers, and therefore were not material rights. The grant of additional licensing rights upon option exercises and contract manufacturing agreements were to be accounted for as separate contracts when or if they occurred.

The Company concluded the Licenses each were considered to be functional as they had significant standalone functionality and were capable of being distinct. However, the Company determined that each of the Licenses individually were not distinct from the Development Services within the context of the agreement. This is because Allergan was dependent on the Company to execute the Development Services, which it was uniquely able to perform, in order for Allergan to benefit from the Licenses. As such, the Company determined that it had four performance obligations under the Allergan Agreement associated with the grant of the four compound Licenses combined with the performance of the Development Services for each of the four compound indications. The Company determined that the four performance obligations would have been performed over the duration of the contract, which began in February 2017 and ends upon receipt of the termination notice. The Company used a cost-based input method to measure proportional performance and to calculate the corresponding amount of revenue to recognize. The Company believed this was the best measure of progress because other measures do not reflect how the Company transfers its performance obligation to Allegan. In applying the cost-based input method of revenue recognition, the Company measured costs incurred relative to budgeted costs to fulfill the four performance obligations. These costs consisted primarily of third-party contract costs and internal labor costs. Revenue will be recognized based on actual costs incurred as a percentage of total budgeted costs as the Company completed its performance obligations.

To allocate transaction price among the four performance obligations, the Company estimated their standalone selling price (SSP) using an income-based valuation approach for the estimated value a licensor of the compounds would receive considering the stage of the compounds' development. A change in the assumptions used to determine its best estimate of selling price for the four performance obligations would not have had a significant effect on the allocation of consideration received to the four performance obligations.

The transaction price at the inception of the agreement and upon adoption of the revenue from contracts with customers guidance was limited to the $50.0 million upfront payment. Of this amount, the Company allocated $12.5 million to each of the four performance obligations. Research and development cost reimbursement payments were included in the transaction price in the reporting period that the Company concludes that it was probable that recording revenue in the period would not have resulted in a significant reversal in amounts recognized. The variable consideration related to the remaining development and commercialization milestone payments was not included in the transaction price as these were fully constrained. As part of the Company's evaluation of the development and commercialization milestones constraint, the Company determined the achievement of such milestones was contingent upon success in future clinical trials and regulatory approvals which was not within its control and uncertain at this stage. Any variable consideration related to sales-based milestones (including royalties) would have been recognized when the related sales occur as they were determined to relate predominantly to the license granted to Allergan. The Company re-evaluated the transaction price in each reporting period and as uncertain events were resolved or other changes in circumstances occurred.

The Company did not incur any significant incremental costs of obtaining the Allergan contract.

For the year ended December 31, 2020, 2019, and 2018 the Company recognized $48.1 million, $16.0 million and $14.8 million respectively, in collaboration revenue associated with the Allergan Agreement. Short-term and long-term deferred revenue contract liabilities related to the Allergan Agreement were $6.4 million and $30.6 million at December 31, 2019, respectively. There were no deferred revenue contract liabilities as of December 31, 2020 due to the Company recognizing a cumulative catch-up adjustment of the remaining deferred revenue balance during the year ended December 31, 2020 for the determined completion of the Company's performance obligations under the Allergan Agreement upon receipt of the notice of termination from AbbVie. Contract asset balances of $1.0 million and $3.4 million were recorded as of December 31, 2020 and 2019, respectively.

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 VBR, ABI-H2158 and ABI-H3733 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 on ABI-H2158 and ABI-H3733 but must provide BeiGene pre-Phase 3 clinical trial know-how and development results if and when such development efforts are completed. If, after ABI-H2158 and ABI-H3733 reach the end of Phase 2 clinical trials, the Company 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, as applicable. Such a termination would result in the Company 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.

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 is 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.

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 ABI-H2158 License, and 3) the transfer of the ABI-H3733 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 ABI-H2158 and ABI-H3733 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 standalone selling price 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 standalone selling price (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 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, 2020. 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.

During the year ended December 31, 2020, the Company recognized $31.0 million as collaboration revenue for the amount allocated to the VBR License as substantial completion of the license technology transfer has occurred. The remaining transaction price allocated to the ABI-H2158 and ABI-H3733 Licenses of $9.0 million was recorded as a long-term deferred revenue contract liability on the consolidated balance sheet as of December 31, 2020. Revenue for these performance obligations will be recognized when the Company provides pre-Phase 3 clinical trial know-how and development results for these compounds to BeiGene or a termination of the BeiGene Agreement for the respective compound.

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 year ended December 31, 2020, 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 December 31, 2020, $2.7 million has been amortized to general and administrative expenses and $0.8 million is included in other assets on the condensed consolidated balance sheet.

Arbutus Agreement

In August 2020, the Company and Arbutus Biopharma Corporation (Arbutus) entered into a Collaboration Agreement (Arbutus Agreement) to conduct a randomized, multi-center, open-label Phase 2 clinical trial to explore the safety, PK 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. Assembly and Arbutus will share responsibility for the costs of the trial equally, excluding manufacturing supply which will be the burden of each company to supply their respective drugs VBR and AB-729.

The Arbutus 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 Agreement and concluded there is one activity, to run an open-label Phase 2 clinical trial, which is akin to performance obligation related to collaborative activities. Reimbursements and cost-sharing portions of this performance obligation will be 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. During the year ended December 31, 2020, the Company recognized a reduction of research and development expense of $0.2 million under the Arbutus Agreement.

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, 2020				
Contract liabilities:				
Deferred revenue	$ 37,048	$ 40,000	$ (68,061)	$ 8,987
Year Ended December 31, 2019				
Contract liabilities:				
Deferred revenue	$ 40,660	$ —	$ (3,612)	$ 37,048

	Year Ended December 31,		
	2020	2019	2018
Collaboration revenue recognized in the period from			
Amounts included in deferred revenue at the beginning of the period	$ 37,048	$ 3,612	$ 5,125
Performance obligations satisfied in previous periods	—	—	—

Note 10 – Strategic License 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 the diligence maintenance fee for that year. A performance milestone totaling $0.1 million was determined to have occurred under this agreement and was paid during the year ended December 31, 2020. Additionally, the Company paid IURTC $0.7 million as a sublicensing fee during the year ended December 31, 2020. The Company made $0.1 million in milestone payments for the year ended December 31, 2018. No milestone payments were incurred or accrued for under this agreement as of and for the year ended December 31, 2019. The milestone and license fees are included in research and development expenses in the consolidated statements of operations and comprehensive loss.

Microbiome Targeted Colonic Delivery Platform

In November 2013, the Company entered into a License and Collaboration Agreement with Therabiome, LLC (Therabiome), for all intellectual property and know-how owned or controlled by Therabiome relating to the oral delivery of pharmaceutical drugs to specific sites in the intestine, using a pH sensitive controlled release capsule-in-capsule technology. The Company will be solely responsible for all research and development activities with respect to any product it develops under the license.

The Company must pay Therabiome clinical and regulatory milestones for each product or therapy advanced from the platform for U.S. regulatory milestones. The Company also must pay Therabiome lesser amounts for foreign regulatory milestones, which vary by country and region. The Company also must pay Therabiome royalties on annual net sales of a product in the low to mid-single digit percentages plus, once annual net sales exceed certain thresholds, a one-time cash payment upon reaching the thresholds.

Therabiome must pay the Company royalties on annual net sales of any product Therabiome is permitted to develop using the intellectual property in the low double to mid-double digit percentages, depending on the level of development or involvement the Company had in the product. Two regulatory milestones resulting in payments totaling $0.4 million were determined to have occurred under this agreement and were paid in the year ended December 31, 2019. No amounts were incurred or accrued for this agreement as of and for the years ended December 31, 2020 and 2018.

In connection with the wind-down of the Microbiome program, the License and Collaboration Agreement with Therabiome was terminated in January 2021.

Door Agreement

In November 2020, the Company and Door Pharmaceuticals, LLC (Door) entered into an exclusive, two-year Collaboration Agreement and Sublicense Agreement (collectively, Door Agreement) focused on the development of a novel class of HBV inhibitors. Under the terms of the agreement, Door will build upon its previous efforts to lead and conduct new discovery research, which Assembly will fund. In return for an up-front payment of $1.8 million, success-based milestones up to $35.0 million, exercise and annual fees ranging from $0.1 million to $2.0 million and royalties in the low to mid-single digits, the Company will be granted an exclusive option to license compounds arising from the collaboration and will be responsible for the continued development and commercialization of optioned compounds. For the period ended December 31, 2020, the Company incurred $0.3 million of research and development funding in addition to the $1.8 million up-front payment.

Under the consolidation accounting standard, the Company determined that Door is a VIE. The Company does not have the power to direct the activities that most significantly affect the economic performance of Door and as such the Company is not the primary beneficiary and consolidation is not required. As of December 31, 2020, the Company has not provided financial or other support to Door that was not contractually required.

Note 11 - Income Taxes

There was no current income tax provision for the years ended December 31, 2020, 2019 and 2018. The deferred income tax expense for the year ended December 31, 2020 was not material. The Company recognized deferred income tax benefit of $0.8 million for the year ended December 31, 2019 and a deferred income tax expense of $1.1 million for the year ended December 31, 2018.

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

	As of December 31,		
	2020	**2019**	**2018**
Statutory federal income tax rate	21.0%	21.0%	21.0%
State taxes, net of federal tax benefit	6.1	5.6	7.1
Stock based compensation	0.7	(3.8)	6.7
Research and development tax credits	2.2	5.6	2.4
State rate change	—	(1.4)	2.5
Uncertain tax positions	2.2	(2.1)	(4.8)
Return to provision adjustments	4.3	(2.5)	4.4
Other	0.1	(0.2)	0.8
Change in valuation allowance	(36.6)	(21.4)	(41.3)
Income taxes provision (benefit)	0.0%	0.8%	(1.2)%

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

	As of December 31,	
	2020	2019
Deferred tax assets:		
Federal and state-operating loss carryforwards	$ 108,236	$ 81,584
Stock-based compensation	16,563	12,347
Intangible assets	1,463	1,774
Deferred revenue	—	9,503
Operating lease liabilities	2,600	3,147
Research and development credits	8,872	7,499
Other	854	702
Total deferred tax assets	138,588	116,556
Valuation allowance	(131,332)	(108,577)
Deferred tax asset, net of valuation allowance	$ 7,256	$ 7,979
Deferred tax liabilities:		
In-process research and development	$ (7,443)	$ (7,439)
Operating lease right-of-use assets	(2,344)	(3,071)
Total deferred tax liabilities	(9,787)	(10,510)
Net deferred tax liability	$ (2,531)	$ (2,531)

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 increase in the valuation allowance for both the years ended December 31, 2020 and 2019 is primarily due to an increase in the Company's federal and state-operating loss carryforwards. The in-process research and development deferred tax liability was recorded in connection with the merger with Assembly Pharmaceuticals, Inc. in 2014 and relates to the difference between the carrying amount of in-process research and development for financial statement purposes relative to the amount used for income tax purposes.

As of December 31, 2020, the Company had potentially utilizable gross federal net operating loss carryforwards of $378.8 million with $264.1 million of net operating losses that carry forward indefinitely and $114.7 million of net operating losses which begin to expire in 2027 if not utilized. There are state net operating loss carryforwards of $446.8 million with $0.7 million carrying forward indefinitely and $446.1 million beginning to expire in 2031. In addition, the Company has federal research and development credit carryforwards of $8.5 million which begin to expire in 2028 if not utilized and California research and development credit carryforwards of $3.6 million, which will carryforward indefinitely.

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, 2019 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, 2018. 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,		
	2020	2019	2018
Balances as of beginning of year	$ 6,070	$ 4,613	$ —
Increases related to prior year tax positions	—	15	3,679
Decreases related to prior year tax positions	(4,162)	(934)	—
Increases related to current year tax positions	747	2,376	934
Balances as of end of year	$ 2,655	$ 6,070	$ 4,613

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 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 12 - Leases

Operating Leases

The Company leases corporate 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. Prior to moving into the South San Francisco office and laboratory space in February 2019, the Company leased office and laboratory space in San Francisco, California, under a sublease that expired in February 2019. The Company also leases office space for administrative functions 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 the Carmel, Indiana lease. The Company also leases office and laboratory space in Groton, Connecticut that supports the Microbiome program under a lease that expires in March 2021. Due to the wind-down of the Microbiome program, the lease will not be renewed. The Company's China subsidiary leases office space and lab space in Shanghai. The lab space expired in December 2020 and the office space expires March 2021, neither of which are being renewed. Additionally, the Company's China subsidiary leases office space in Beijing under a lease agreement that expires in December 2021. 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 2023. In February 2021, the Company purchased substantially all of the leased equipment used for the Microbiome program from its leasing agency and sold them to a third party. The loss on the sale is equal to the impairment loss the Company recognized on these assets for the year ended December 31, 2020 of $0.7 million.

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, 2020, the Company had operating lease liabilities of $10.1 million and right-of-use assets of $9.1 million.

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

	Year Ended December 31,	
	2020	2019
Lease cost		
Operating lease cost	$ 5,214	$ 4,454
Short-term lease cost	401	609
Variable lease cost	1,468	1,193
Total lease cost	$ 7,083	$ 6,256

	Year Ended December 31,	
	2020	2019
Operating cash flows from operating leases	$ 4,513	$ 4,269
Right-of-use assets exchanged for new operating lease liabilities	$ 1,302	$ 15,261

As of December 31, 2020, the weighted-average remaining lease term for operating leases was 2.7 years and the weighted-average discount rate for operating leases was 9.2%.

As of December 31, 2020, the maturities of the Company's operating lease liabilities were as follows (in thousands):

2021	$ 4,369
2022	3,905
2023	3,502
Total	11,776
Less: present value discount	(1,647)
Operating lease liabilities	$ 10,129

Operating lease costs were $7.1 million, $6.3 million and $4.2 million for the years ended December 31, 2020, 2019 and 2018, respectively.

Note 13 - 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. In 2020, 2019 and 2018, the Company made discretionary matching contributions of $0.9 million, $0.7 million and $0.7 million, respectively.

Note 14 - Selected Quarterly Financial Data (Unaudited)

The following table contains quarterly financial information for the four quarters of 2020 and 2019 which has been prepared in accordance with GAAP for interim financial information. The Company believes that the following information reflects all normal recurring adjustments necessary for a fair statement of the information for the periods presented.

	2020 Quarter Ended			
	March 31	June 30	September 30	December 31
	(in thousands except for per share amounts)			
Collaboration revenue	$ 4,081	$ 39,376	$ 34,611	$ 1,037
Operating expenses	$ 31,775	$ 32,797	$ 38,630	$ 40,679
Interest and other income	$ 1,039	$ 691	$ 670	$ 224
Net income (loss)	$ (26,655)	$ 7,270	$ (3,349)	$ (39,418)
Unrealized gain (loss) from marketable securities, net of tax	$ 115	$ 190	$ (262)	$ (112)
Basic net income (loss) per common share	$ (0.76)	$ 0.21	$ (0.09)	$ (1.11)
Diluted net income (loss) per common share	$ (0.76)	$ 0.19	$ (0.09)	$ (1.11)

	2019 Quarter Ended			
	March 31	June 30	September 30	December 31
	(in thousands except for per share amounts)			
Collaboration revenue	$ 3,885	$ 3,080	$ 4,231	$ 4,767
Operating expenses	$ 32,221	$ 22,780	$ 30,224	$ 33,451
Interest and other income	$ 1,276	$ 1,182	$ 983	$ 859
Net loss	$ (27,052)	$ (18,503)	$ (24,995)	$ (27,084)
Unrealized gain (loss) from marketable securities, net of tax	$ 108	$ 52	$ (18)	$ 4
Basic and diluted net loss per common share	$ (1.05)	$ (0.72)	$ (0.96)	$ (0.99)

Note 15 – Subsequent Events

Subsequent to December 31, 2020, the Company sold 4,177,080 shares of common stock through its 2020 ATM resulting in net proceeds of $25.5 million.

CORPORATE INFORMATION

Directors

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

Gina Consylman
Chief Financial Officer, Ironwood Pharmaceuticals, Inc.

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

Myron Z. Holubiak
President and Chief Executive Officer, Citius Pharmaceuticals, Inc.

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

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

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

Corporate Headquarters
331 Oyster Point Blvd., Fourth Floor
South San Francisco, California 94080
+1.833.509.4583

Website
www.assemblybio.com

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

Executive Officers

John G. McHutchison, A.O., M.D.
Chief Executive Officer and President

Thomas J. Russo, CFA
Chief Financial Officer

Jason A. Okazaki
Chief Legal and Business Officer

Luisa Stamm, M.D., Ph.D.
Chief Medical Officer

William E. Delaney IV, Ph.D.
Chief Scientific Officer

Transfer Agent
American Stock Transfer & Trust Company
6201 15th Avenue
Brooklyn, New York 11219

331 Oyster Point Boulevard
4th Floor
South San Francisco, CA 94080

assemblybio.com