UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 10-Q

☒ **QUARTERLY REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the quarterly period ended March 31, 2023

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 as 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)	(zip code)

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

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common Stock, par value $0.001	ASMB	The Nasdaq Global Select Market

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 (§232.405 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 is a shell company (as defined in Rule 12b-2 of the Exchange Act). Yes ☐ No ☒

As of May 1, 2023, there were 52,121,309 shares of the registrant's common stock outstanding.

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References to Assembly Biosciences, Inc.

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

Forward-Looking Statements

This Quarterly Report on Form 10-Q contains "forward-looking statements" that are subject to certain risks and uncertainties, including, without limitation, those set forth in Part I, Item 1A of our Annual Report on Form 10-K filed with the U.S. Securities and Exchanges Commission (SEC) on March 22, 2023 (2022 Annual Report) and Part II, Item 1A of this Quarterly Report on Form 10-Q under the heading "Risk Factors," that could cause actual results to materially differ. Such risks and uncertainties include, among other things:

- our ability to maintain financial resources necessary to continue our research activities, clinical studies and other business operations;
- our ability to initiate and complete clinical studies involving our therapeutic product candidates, including studies contemplated by collaboration agreements, in the anticipated timeframes;
- safety and efficacy data from clinical or nonclinical studies may not warrant further development of our product candidates;
- clinical and nonclinical data presented at conferences may not differentiate our product candidates from other companies' candidates; and
- results of nonclinical studies may not be representative of disease behavior in a clinical setting and may not be predictive of the outcomes of clinical studies.

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

PART I - FINANCIAL INFORMATION
Item 1. Financial Statements

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

	March 31, 2023	December 31, 2022
	(Unaudited)	
ASSETS		
Current assets		
Cash and cash equivalents	$ 43,482	$ 52,418
Marketable securities	29,534	39,192
Accounts receivable from collaboration	717	944
Prepaid expenses and other current assets	6,011	4,413
Total current assets	79,744	96,967
Property and equipment, net	619	743
Operating lease right-of-use (ROU) assets	2,419	3,195
Other assets	334	889
Total assets	**$ 83,116**	**$ 101,794**
LIABILITIES AND STOCKHOLDERS' EQUITY		
Current liabilities		
Accounts payable	$ 1,224	$ 2,493
Accrued research and development expenses	3,046	3,122
Other accrued expenses	3,154	7,317
Operating lease liabilities - short-term	2,546	3,364
Total current liabilities	9,970	16,296
Deferred revenue	2,733	2,733
Operating lease liabilities - long-term	80	101
Total liabilities	**12,783**	**19,130**
Commitments and contingencies		
Stockholders' equity		
Preferred stock, $0.001 par value; 5,000,000 shares authorized; no shares issued or outstanding	—	—
Common stock, $0.001 par value; 150,000,000 shares authorized as of March 31, 2023 and December 31, 2022; 52,015,268 and 48,894,973 shares issued and outstanding as of March 31, 2023 and December 31, 2022, respectively	52	49
Additional paid-in capital	814,264	807,938
Accumulated other comprehensive loss	(513)	(803)
Accumulated deficit	(743,470)	(724,520)
Total stockholders' equity	70,333	82,664
Total liabilities and stockholders' equity	**$ 83,116**	**$ 101,794**

See Accompanying Notes to Condensed Consolidated Financial Statements

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

	Three Months Ended March 31,	
	2023	**2022**
Operating expenses		
Research and development	$ 14,547	$ 17,205
General and administrative	5,012	5,957
Total operating expenses	19,559	23,162
Loss from operations	**(19,559)**	**(23,162)**
Other income		
Interest and other income, net	609	71
Total other income	609	71
Net loss	**$ (18,950)**	**$ (23,091)**
Other comprehensive loss		
Unrealized gain (loss) on marketable securities	290	(489)
Comprehensive loss	**$ (18,660)**	**$ (23,580)**
Net loss per share, basic and diluted	$ (0.37)	$ (0.48)
Weighted average common shares outstanding, basic and diluted	51,012,450	48,123,930

See Accompanying Notes to Condensed Consolidated Financial Statements

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

	Common Stock		Additional Paid-in Capital	Accumulated Other Comprehensive Loss	Accumulated Deficit	Total Stockholders' Equity
	Shares	Amount				
Balance as of December 31, 2022	**48,894,973**	**$ 49**	**$ 807,938**	**$ (803)**	**$ (724,520)**	**$ 82,664**
Issuance of common stock under at-the-market (ATM) equity offering program, net of issuance costs	3,050,446	3	4,489	—	—	4,492
Issuance of common stock for settlement of restricted stock units (RSUs)	69,849	—	—	—	—	—
Unrealized gain on marketable debt securities	—	—	—	290	—	290
Stock-based compensation	—	—	1,837	—	—	1,837
Net loss	—	—	—	—	(18,950)	(18,950)
Balance as of March 31, 2023	**52,015,268**	**$ 52**	**$ 814,264**	**$ (513)**	**$ (743,470)**	**$ 70,333**

	Common Stock		Additional Paid-in Capital	Accumulated Other Comprehensive Loss	Accumulated Deficit	Total Stockholders' Equity
	Shares	Amount				
Balance as of December 31, 2021	**48,120,437**	**$ 48**	**$ 800,728**	**$ (419)**	**$ (631,428)**	**$ 168,929**
Issuance of common stock for settlement of RSUs	12,500	—	—	—	—	—
Unrealized loss on marketable debt securities	—	—	—	(489)	—	(489)
Stock-based compensation	—	—	1,442	—	—	1,442
Net loss	—	—	—	—	(23,091)	(23,091)
Balance as of March 31, 2022	**48,132,937**	**$ 48**	**$ 802,170**	**$ (908)**	**$ (654,519)**	**$ 146,791**

See Accompanying Notes to Condensed Consolidated Financial Statements

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

	Three Months Ended March 31,	
	2023	**2022**
Cash flows from operating activities		
Net loss	$ (18,950)	$ (23,091)
Adjustments to reconcile net loss to net cash used in operating activities:		
Depreciation and amortization	124	120
Stock-based compensation	1,835	1,443
Net (accretion) amortization of investments in marketable debt securities	(52)	149
Non-cash rent expense	855	893
Changes in operating assets and liabilities:		
Accounts receivable from collaboration	227	(188)
Prepaid expenses and other current assets	(1,598)	(12)
Other assets	555	(472)
Accounts payable	(1,269)	(1,252)
Accrued research and development expenses	(76)	196
Other accrued expenses	(4,161)	(4,365)
Operating lease liabilities	(918)	(923)
Net cash used in operating activities	(23,428)	(27,502)
Cash flows from investing activities		
Proceeds from maturities of marketable securities	10,000	30,000
Proceeds from sale of marketable securities	—	7,000
Purchases of marketable securities	—	(3,951)
Net cash provided by investing activities	10,000	33,049
Cash flows from financing activities		
Proceeds from the issuance of common stock under ATM equity offering program, net of issuance costs	4,492	—
Net cash provided by financing activities	4,492	—
Net (decrease) increase in cash and cash equivalents	(8,936)	5,547
Cash and cash equivalents at the beginning of the period	52,418	45,627
Cash and cash equivalents at the end of the period	**$ 43,482**	**$ 51,174**

See Accompanying Notes to Condensed 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 biotechnology company developing innovative antiviral therapeutics with the potential to improve the lives of patients worldwide by targeting serious viral diseases, including high-recurrence genital herpes, transplant-related herpesviruses, chronic hepatitis delta virus (HDV) infection and chronic hepatitis B virus (HBV) infection. The Company operates in one segment and is headquartered in South San Francisco, California.

The Company has a broad research and development portfolio with multiple targets, including (1) a long-acting helicase inhibitor for the treatment of high-recurrence genital herpes, (2) a pan-herpes non-nucleoside polymerase inhibitor to treat multiple transplant-associated herpesvirus infections, (3) a small molecule approach to inhibit cell entry for both HDV and HBV, (4) a small molecule interferon-α receptor agonist designed to selectively activate the interferon-α pathway within the liver and offer the convenience of oral dosing and (5) small molecule core inhibitors that inhibit the HBV replication cycle and block the generation of covalently closed circular DNA (cccDNA).

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 these unaudited condensed consolidated financial statements are issued. If the Company cannot generate significant cash from its operations, it intends to obtain any additional funding it requires through strategic relationships, public or private equity or debt financings, grants or other arrangements. The Company cannot assure such funding will be available on reasonable terms, if at all. Market volatility, inflation or other factors could also adversely impact the Company's ability to access capital when and as needed.

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

Note 2 - Summary of Significant Accounting Policies

Basis of Presentation

The accompanying unaudited condensed consolidated financial statements include the accounts of the Company and its subsidiaries. All intercompany balances and transactions have been eliminated in consolidation.

The accompanying unaudited condensed consolidated financial statements have been prepared in accordance with the accounting principles generally accepted in the United States of America (U.S. GAAP) for interim financial information and pursuant to the instructions to Form 10-Q and Rule 10-01 of Regulation S-X of the SEC. In management's opinion, the unaudited condensed consolidated financial statements have been prepared on the same basis as the annual audited consolidated financial statements and include normal recurring adjustments necessary for the fair presentation of the Company's financial position and its results of operations and comprehensive loss and its cash flows for the periods presented. These statements do not include all disclosures required by U.S. GAAP and should be read in conjunction with the Company's audited consolidated financial statements and accompanying notes for the fiscal year ended December 31, 2022, which are contained in the 2022 Annual Report. The results for the three

months ended March 31, 2023 are not necessarily indicative of results to be expected for the entire year ending December 31, 2023 or future operating periods.

Use of Estimates

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

Significant estimates inherent in the preparation of the accompanying unaudited condensed consolidated financial statements include estimates of costs incurred but not yet invoiced for research and development accruals.

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

Other Risks and Uncertainties

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

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

In April 2023, the Company announced it was evaluating potential partnering options for its core inhibitor portfolio. If the Company is unable to reach an agreement with a suitable collaboration partner for its core inhibitors or any such agreement has unfavorable terms, the Company may be unable to advance the product candidates through further clinical development.

Net Loss per Share

Basic net loss per share of common stock excludes dilution and is computed by dividing net loss by the weighted average number of shares of common stock outstanding during the period. Diluted net loss per share of common stock 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.

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

	Three Months Ended March 31,	
	2023	2022
Numerator:		
Net loss	$ (18,950)	$ (23,091)
Denominator:		
Weighted average common shares outstanding - basic and diluted	51,012,450	48,123,930
Net loss per share - basic and diluted	$ (0.37)	$ (0.48)

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

	March 31,	
	2023	2022
Options to purchase common stock	10,517,404	7,475,876
Common stock subject to purchase under ESPP	92,889	129,107
Unvested RSUs	1,718,173	1,553,755
Total	12,328,466	9,158,738

Recently Adopted Accounting Standards

In June 2016, the Financial Accounting Standards Board (the FASB) issued Accounting Standards Update (ASU) No. 2016-13, *Instruments – Credit Losses: Measurement of Credit Losses on Financial Instruments* (ASU 2016-13), which requires expected credit losses relating to financial assets measured on an amortized cost basis and available-for-sale debt securities be recorded through an allowance for credit losses. ASU 2016-13 limits the amount of credit losses to be recognized for available-for-sale debt securities to the amount by which carrying value exceeds fair value and requires the reversal of previously recognized credit losses if fair value increases. The FASB issued additional amendments to the new guidance related to transition and clarification and 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. The Company adopted ASU 2016-13 effective January 1, 2023 on a modified retrospective basis. The Company elected to exclude accrued interest receivable from the amortized cost basis of its available-for-sale debt securities and to not measure an allowance for credit losses for accrued interest receivable. The adoption of ASU 2016-13 did not have a material impact on the Company's consolidated financial statements.

Note 3 – Fair Value Measurements and Investments in Marketable Securities

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 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 that 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.

Investments in marketable securities consisted of the following (in thousands):

	March 31, 2023			
	Amortized Cost	Gross Unrealized Gain	Gross Unrealized Loss	Fair Value
Cash equivalents				
Money market fund	$ 42,374	$ —	$ —	$ 42,374
Total cash equivalents	42,374	—	—	42,374
Short-term marketable securities				
U.S. and foreign corporate debt securities	14,853	—	(112)	14,741
U.S. treasury securities	8,992	—	(128)	8,864
U.S. and foreign commercial paper	5,929	—	—	5,929
Total short-term marketable securities	29,774	—	(240)	29,534
Total cash equivalents and marketable securities	$ 72,148	$ —	$ (240)	$ 71,908

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

As of March 31, 2023 and 2022, investments which were in an unrealized loss position were not material and were not the result of a decline in credit quality. Unrealized losses are generally due to interest rate fluctuations, as opposed to declines in credit quality. The Company determined it has the intent and ability to hold all marketable securities that have been in a continuous loss position until recovery of their amortized cost basis, which may be until maturity. As a result, the Company did not recognize any credit losses related to its investments and all unrealized gains and losses on available-for-sale securities are recorded in accumulated other comprehensive loss on the condensed consolidated balance sheets during the three months ended March 31, 2023 and 2022.

Accrued interest receivable was $0.2 million as of March 31, 2023 and 2022, and was recorded in prepaid expenses and other current assets on the condensed consolidated balance sheets. The Company did not write off any accrued interest receivable during the three months ended March 31, 2023.

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

	March 31, 2023			
	Level 1	Level 2	Level 3	Fair Value
Cash equivalents				
Money market fund	$ 42,374	$ —	$ —	$ 42,374
Total cash equivalents	42,374	—	—	42,374
Short-term marketable securities				
U.S. and foreign corporate debt securities	—	14,741	—	14,741
U.S. treasury securities	—	8,864	—	8,864
U.S. and foreign commercial paper	—	5,929	—	5,929
Total short-term marketable securities	—	29,534	—	29,534
Total assets measured at fair value	$ 42,374	$ 29,534	$ —	$ 71,908

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

The Company estimates the fair value of its investments in marketable securities 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 were no transfers between Level 1, Level 2 or Level 3 during the periods presented.

Note 4 – Other Accrued Expenses

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

	March 31, 2023	December 31, 2022
Accrued expenses:		
Accrued compensation	$ 2,498	$ 6,228
Accrued restructuring charges	344	599
Accrued professional fees and other	312	490
Total accrued expenses	$ 3,154	$ 7,317

Note 5 – Restructuring

In July 2022, the Company and its board of directors approved a strategic plan to align with its refocused pipeline on its next generation core inhibitors and research programs and reduced its workforce by approximately 30%. The Company expects to incur total restructuring charges of $1.1 million. Restructuring charges consist solely of employee severance and related benefits which include $1.0 million in severance payments to executive officers impacted by the restructuring, $0.8 million in one-time termination severance payments and other employee-related costs associated with the restructuring and a reversal of $0.7 million for previously recognized stock-based compensation expense related to forfeited awards based on the Company's policy of recognizing stock-based awards with graded vesting schedules using an accelerated attribution method on a straight-line basis over the requisite service period for each separately vesting portion of the award and to recognize forfeitures when they occur.

There were no restructuring charges incurred during the three months ended March 31, 2023. The Company incurred cumulative restructuring charges of $1.1 million through March 31, 2023.

A summary of accrued restructuring charges, included as a component of other accrued expenses on the Company's condensed consolidated balance sheet as of March 31, 2023, is as follows (in thousands):

	Employee Severance and Related Benefits	Asset Impairment and Other Costs	Total Accrued Restructuring Charges
Accrued balance as of December 31, 2022	$ 599	$ —	$ 599
Reductions for cash payments	(255)	—	(255)
Accrued balance as of March 31, 2023	$ 344	$ —	$ 344

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

Note 6 – Sale of Common Stock

In August 2020, 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), pursuant to its shelf registration statement on Form S-3 on file with the SEC. During the three months ended March 31, 2023, the Company sold 3,050,446 shares of common stock under the 2020 ATM, for which the Company received net proceeds of $4.5 million, after deducting commissions, fees and expenses. The Company did not sell any shares of common stock under the 2020 ATM during the three months ended March 31, 2022.

Note 7 – Stock-Based Compensation

The following table summarizes the components of total stock-based compensation expense included in the condensed consolidated statements of operations and comprehensive loss (in thousands):

	Three Months Ended March 31,	
	2023	2022
Research and development	$ 910	$ 778
General and administrative	925	665
Total stock-based compensation expense	$ 1,835	$ 1,443

As of March 31, 2023, there was $7.1 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 1.7 years.

The fair value of stock options granted or modified during the periods indicated was estimated using the Black-Scholes option pricing model, based on the following assumptions:

	Three Months Ended March 31,	
	2023	2022
Exercise price	$0.89 - $1.53	$1.53 - $2.45
Expected volatility	77.5% - 82.8%	79.2% - 81.6%
Risk-free rate	3.59% - 4.00%	1.41% - 2.48%
Expected term (years)	5.5 - 7.0	5.5 - 7.5
Expected dividend yield	0%	0%

Note 8 - Collaboration Agreements

BeiGene Agreement

In July 2020, the Company and BeiGene, Ltd. (BeiGene) entered into a Collaboration Agreement (the BeiGene Agreement) to develop and commercialize the Company's novel core inhibitor product candidates vebicorvir (VBR), ABI-H2158 and ABI-H3733 (the Licensed Product Candidates) for chronic HBV infection in the People's Republic of China, Hong Kong, Taiwan and Macau.

As of March 31, 2023, the only remaining performance obligation under the BeiGene Agreement not considered to be complete is the transfer of the ABI-H3733 License. The transaction price allocated to ABI-H3733 of $2.7 million was recognized as a long-term deferred revenue contract liability as of March 31, 2023 and December 31, 2022, and will be recognized as revenue when the Company provides pre-Phase 3 clinical study know-how and development results for ABI-H3733 to BeiGene or a termination of the BeiGene Agreement for ABI-H3733. During the three months ended March 31, 2023 and 2022, the Company did not recognize any revenue or 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 in 2020. 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 March 31, 2023 and December 31, 2022, the remaining unamortized contract costs are $0.2 million and are included in other assets on the condensed consolidated balance sheet.

Arbutus Biopharma Agreement

In August 2020, the Company and Arbutus Biopharma Corporation (Arbutus Biopharma) entered into a Clinical Trial Collaboration Agreement (the Arbutus Biopharma Agreement) to conduct a randomized, multi-center, open-label Phase 2 clinical trial to explore the safety, pharmacokinetics and antiviral activity of the triple combination of VBR, AB-729 and a nucleos(t)ide analog reverse transcriptase inhibitor (NrtI) compared to the double combinations of VBR with a NrtI and AB-729 with a NrtI. Under the Arbutus Biopharma Agreement, Assembly and Arbutus Biopharma share responsibility for the costs of the trial equally, excluding manufacturing supply which are the burden of each company to supply their respective drugs, VBR and AB-729. Assembly is responsible for conducting this clinical trial with Arbutus Biopharma reimbursing Assembly its share of expenses. In February 2023, Assembly and Arbutus Biopharma decided to terminate the Phase 2 clinical trial early, at the end of the 48-week on-treatment period, and are in the process of closing the study.

Reimbursements and cost-sharing portions from Arbutus Biopharma are reflected as a reduction of research and development expense when realized in the Company's condensed consolidated statements of operations. During both the three months ended March 31, 2023 and 2022, the Company recognized a reduction of research and development expenses of $0.6 million under the Arbutus Biopharma Agreement.

Note 9 - Milestones and Research Agreements

HBV Research Agreement with Indiana University

Since September 2013, the Company has been party to an exclusive License Agreement dated September 3, 2013 with Indiana University Research and Technology Corporation (IURTC) from whom it has licensed aspects of the Company's HBV program held by IURTC. The license agreement requires the Company to make milestone payments based upon the successful accomplishment of clinical and regulatory milestones. The aggregate amount of all performance milestone payments under the IURTC license agreement, should all milestones through development be met, is $0.8 million, with a portion having been paid. The Company is obligated to pay IURTC royalty payments based on net sales of the licensed technology as well as a portion of any sublicensing revenue Assembly receives. The Company is also required to pay diligence maintenance fees each year to the extent that the royalty, sublicensing, and milestone payments to IURTC are less than such fees for that year. The Company paid IURTC $0.1 million in diligence maintenance fees during both the three months ended March 31, 2023 and 2022.

Item 2. Management's Discussion and Analysis of Financial Condition and Results of Operations

The condensed consolidated financial statements and this Management's Discussion and Analysis of Financial Condition and Results of Operations should be read in conjunction with the consolidated financial statements and notes thereto for the year ended December 31, 2022 and the related Management's Discussion and Analysis of Financial Condition and Results of Operations, both of which are contained in our Annual Report on Form 10-K for the fiscal year ended December 31, 2022 filed with the U.S. Securities and Exchange Commission on March 22, 2023 (2022 Annual Report). In addition to historical information, this discussion and analysis 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 under "Part I. Item 1A. Risk Factors" in our 2022 Annual Report and "Part II. Item 1A. Risk Factors" in this report.

Overview

We are a biotechnology company developing innovative antiviral therapeutics targeting serious viral diseases, including candidates with the potential to improve the lives of patients worldwide. Our pipeline includes an early-stage development program targeting high-recurrence genital herpes, research programs focused on the discovery of antivirals to treat devastating viral diseases, including hepatitis delta virus (HDV) and transplant-related herpesviruses, and two clinical core inhibitor (CI) candidates designed to disrupt the replication cycle of hepatitis B virus (HBV) at several key points with the aim of achieving finite treatment and functional cures.

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

In April 2023, we announced the evaluation of potential partnering options for our CI portfolio prior to further clinical advancement and prioritization of our broader antiviral pipeline, including ABI-5366 (5366), our recently announced development candidate for our HSV-2 long-acting helicase-primase inhibitor program.

Our Herpesvirus Programs

In August 2022, we introduced our first programs outside of hepatitis, which target high-recurrence genital herpes and transplant-associated herpesviruses. In February 2023, we announced the nomination of our first herpesvirus development candidate, 5366, a long-acting helicase-primase inhibitor for treatment of high-recurrence genital herpes, to progress to IND-enabling studies.

High-Recurrence Genital Herpes/HSV-2

Genital herpes can be caused by either herpes simplex virus type 1 (HSV-1) or herpes simplex virus type 2 (HSV-2), with approximately 80% of genital herpes caused by HSV-2. Acquired by oral or genital contact, HSV replicates rapidly in neurons, where it can remain latent for the rest of the patient's life. Initial infection can be asymptomatic or can be marked by symptoms including localized pain and painful lesions. Recurrence is common and can cause symptomatic recurrences of painful genital lesions that can lead to increased transmission and can debilitate patients; symptoms may become more serious with additional episodes. Additional complications include increased risk of HIV infection, as well as associated psychological stress and isolationary thoughts. Immunocompromised patients may experience more severe and prolonged symptoms due to increased recurrence rates. While genital herpes can be caused by either HSV-1 or HSV-2, recurrences are more likely to be experienced by patients infected by HSV-2.

Globally, approximately 500 million people aged 15 to 49 have been infected with HSV-2, with approximately 110 million of those patients in the United States and Europe. There is limited data available for ages over 50. While prevalence is high, up to 90% of HSV-2 infections in the United States are estimated to be undiagnosed since a significant number of cases are asymptomatic. Genital herpes can be sexually transmitted during both symptomatic and asymptomatic reactivation of the virus. High recurrence genital herpes, defined as six or more recurrences annually, is estimated to affect approximately 40% of diagnosed HSV-2 genital herpes patients following their first outbreak.

Helicase-primase inhibitors are antiviral agents in development for HSV-1 and HSV-2, with a novel mechanism of action that has been clinically validated. They inhibit the viral protein complex consisting of helicase, primase, and cofactor subunits, which have functions that are essential for viral DNA replication and are conserved across HSV-1 and HSV-2. These agents are not nucleoside analogues and do not require phosphorylation by the HSV thymidine kinase (TK) to become active drugs; therefore, helicase-primase inhibitors are active immediately upon reactivation of latent HSV-1 and HSV-2. Furthermore, helicase-primase inhibitors are active against TK-deficient HSV-1 and HSV-2, which is a major mechanism of resistance to nucleoside analogues.

Currently, there are three antiviral drugs (all nucleoside analogs) approved in the United States and the European Union for the treatment of genital herpes. In addition to the approved nucleoside analogs, agents such as local anesthetics or analgesics may be used to alleviate local symptoms of minor pain and discomfort.

Nucleoside analogs can be administered as episodic therapy as individual outbreaks arise or daily as chronic suppressive therapy for those with high post-exposure recurrences. However, these agents have a high daily pill burden and are only partially effective at controlling the infection or reducing transmission risk. There are still high titer (greater than 10^4 HSV-2 DNA copies) shedding episodes under this current standard of care for HSV-2, which can lead to recurrences and transmission of genital herpes. For high-recurrence genital herpes patients receiving daily suppressive therapy of oral nucleoside analogs, less than 35% remained recurrence free after 12 months.

Due to the limitations of current therapies, we identified an opportunity to develop a potent, long-acting helicase inhibitor for high-recurrence genital herpes with the potential to improve efficacy, convenience and patient compliance.

In February 2023, we nominated 5366 as a development candidate for our long-acting helicase inhibitor program. In nonclinical studies, 5366 has demonstrated high potential to serve as a long-acting agent, including low nanomolar potency in vitro against the HSV helicase and exceptionally low clearance. This preclinical profile has led us to target 5366 for development as a long-acting treatment with the potential to be administered orally or as an injectable. We currently anticipate the initiation of clinical studies of 5366 in the first half of 2024.

Transplant-Associated Herpesviruses

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

As with HSV-2, there are approved antivirals that are administered in a transplant setting. However, currently approved antivirals are not broad spectrum and pose the risk of potentially serious side effects and drug-drug interactions. As a result of these limitations, we identified an opportunity to develop an oral pan-herpes NNPI for these transplant-associated herpesvirus infections, which would greatly advance treatment. Our research team has discovered multiple series of potent, broad-spectrum herpesvirus polymerase inhibitors.

Our HBV and HDV Programs

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

HDV is a “satellite virus,” because it can only infect people (1) who are already infected with HBV or (2) at the same time as a person is infected with HBV. HDV impacts a subset of approximately 12 million HBV patients. These patients, which only comprise an estimated 4.5% of hepatitis B surface antigen (HBsAg) positive patients, experience a substantially increased disease burden, as they account for 18% of cirrhosis and 20% of hepatocellular carcinoma associated with HBV. While HDV is less prevalent in the United States, it is a significant and serious health problem with inadequate treatment in many parts of Europe, Africa, the Middle East, East Asia and parts of South America. HDV is known to accelerate disease progression and increase the incidence of liver cirrhosis and liver cancer, which results in higher morbidity and mortality rates than HBV alone.

The current standard of care for chronic HBV infection, nucleos(t)ide analog reverse transcriptase inhibitors (NrtIs), are taken life-long and reduce, but do not eliminate, the virus and result in very low cure rates. No new mechanisms of action (MOA) have been approved for chronic HBV infection in over 25 years. The current standard of care treatment for HDV is off-label pegylated IFN-α injected weekly or, in some regions, a large, complex molecule that requires daily injections. There are no approved HDV treatments in the United States.

The focus of our HBV/HDV programs is to improve outcomes and increase the number of patients diagnosed and treated through the development of finite and curative therapies for HBV and to advance programs targeting HDV, due to the immediate disease burden facing these patients.

HBV/HDV Entry Inhibitor

HDV is a small RNA virus that encodes just two viral proteins and relies on host enzymes as well as the HBsAg from HBV to replicate, which limits the number of HDV-specific antiviral targets. Similar to HBV, HDV utilizes HBsAg to enter hepatocytes by binding the cellular transmembrane protein sodium taurocholate co-transporting peptide (NTCP). NTCP is highly expressed on human hepatocytes, where it serves as one of several proteins involved in the transport of bile acids. The binding of specific small or large molecules to NTCP has been shown to effectively inhibit the interaction of HBsAg with NTCP, which prevents HBV and HDV from infecting hepatocytes. The inhibition of HBV and HDV infection by molecules that bind NTCP has been demonstrated in vitro, in animal models and clinically. The binding of NTCP-targeted HBV/HDV entry inhibitors to NTCP has also been shown to inhibit the transport of certain bile acids into cells which results in plasma elevations of bile acids; this effect has been well tolerated clinically and may serve as a biomarker of pharmacologically active concentrations of drug in the plasma.

In March 2022, we announced our research program focused on a novel, orally bioavailable small molecule approach to inhibit entry of HBV and HDV by targeting NTCP. We believe a safe and effective oral small molecule entry inhibitor would be a significant innovation for patients living with HDV and could significantly improve treatment uptake and diagnosis rates, especially when compared with currently available injectable products. At AASLD 2022, we presented the preclinical characterization of our novel class of highly potent small molecule HBV/HDV entry inhibitors.

IFNAR Agonist

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

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

Core Inhibitors

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

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

Our research and development organizations have advanced our two next-generation CIs, 4334 and 3733, through Phase 1a and Phase 1b, respectively. These candidates, which exhibit multiple MOAs, have been optimized to potently disrupt both viral replication (MOA #1) and, importantly, prevent the establishment and replenishment of new cccDNA (MOA #2). cccDNA is the viral reservoir that drives HBV's life-long persistence in patients. First-generation CIs have not demonstrated adequate potency to sufficiently block its formation. Further, the current standard of care, NrtIs, can only inhibit production of new virus, and it does so incompletely.

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

In April 2023, we announced that, despite promising results in both a Phase 1a clinical study of 4334 and a Phase 1b clinical study of 3733, we will evaluate partnering options for our CI portfolio prior to pursuing further clinical development of 4334 and 3733. We believe that partnering our CI portfolio will enable additional opportunities for further clinical development for CIs aimed at achieving a functional cure for chronic HBV infection, including combination approaches.

4334

In mid-2021, we announced the selection of 4334 for clinical development. As with all of our CI product candidates nominated after VBR, 4334 was internally discovered and developed. In addition, the chemical scaffold of 4334 is also novel and distinct from 3733 and our two first-generation CIs, VBR, which is licensed from Indiana University, and ABI-H2158 (2158).

We nominated 4334 based on a preclinical target drug profile that indicates enhanced target coverage and potency against both MOA #1 and MOA #2. We believe that 4334 has a best-in-class preclinical profile, with single-digit nanomolar potency against the production of new virus and the formation of cccDNA. Preclinically to date, 4334 has also demonstrated pan-genotypic activity, an improved resistance profile and a favorable safety profile. Preclinical characterization of 4334 was shared in a poster presentation at AASLD The Liver Meeting® in November 2021 (AASLD 2021). At the European Association for the Study of the Liver's (EASL) International Liver Congress™ in June 2022 (EASL 2022), we presented preclinical data demonstrating that 4334 promotes formation of empty capsids and prevents cccDNA formation by disrupting incoming capsids. At AASLD 2022, we presented preclinical data demonstrating that 4334 also accelerates capsid assembly and inhibits cccDNA formation through multiple pathways and showed that 4334 can prematurely disrupt capsids containing dendrimer-like-DNA, which has the potential to impact HBV integration.

In October 2022, we initiated a Phase 1a clinical study of 4334 to evaluate safety, tolerability and pharmacokinetics (PK) following single ascending dose and multiple ascending dose administration in healthy subjects in New Zealand. We shared interim data from this Phase 1a trial at three time points: (1) as of mid-December 2022 for the initial 30 mg single dose cohort; (2) as of mid-March 2023 for all remaining single dose cohorts (100 mg, 200 mg and 400 mg) and the first 100 mg multiple-dose cohort; and (3) as of April 2023 for the final 200 mg multiple-dose cohort. Data are pending for a food effect cohort at 200 mg.

Based on data available for the single-dose and multiple-dose cohorts as of mid-April 2023, 4334 had a mean half-life supporting once-a-day dosing. Based on the PK data from these cohorts and preclinical studies, daily minimum plasma trough concentrations (C_{min}) were projected to achieve double-digit multiples of the protein-adjusted EC_{50} for both MOAs with the 200 mg QD dose projected to achieve greater than 30 times the protein adjusted EC_{50} for cccDNA formation.

Through mid-April 2023, treatment-emergent adverse events (AEs) and laboratory abnormalities were mild to moderate, with the majority being mild, and there were no patterns of AEs or laboratory abnormalities noted to be associated with 4334 and no clinically significant ECG abnormalities were reported.

3733

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

In preclinical studies, 3733 has demonstrated pan-genotypic activity and an improved resistance profile, as well as significantly increased potency against both MOA #1 and MOA #2 and target coverage as compared to both VBR and 2158. In 2020, we initiated and completed a Phase 1a clinical study of 3733 to evaluate safety, tolerability and PK following single ascending dose and multiple ascending dose administration in healthy subjects in New Zealand. Data indicated that 3733 was generally well-tolerated and had favorable PK. Results detailing 3733's safety and PK from this study were presented in a poster presentation at AASLD 2021. In 2021, following the completion of the Phase 1a trial, our chemistry, manufacturing and controls organization developed a new tablet formulation to support Phase 1b for 3733. At EASL 2022, we presented 3733's improved PK profile resulting from the new formulation activities mentioned above.

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

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

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

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

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

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

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

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

Operations

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

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

We have generated significant losses to date, and we expect to continue to generate losses as we develop our product candidates. As of March 31, 2023, we had an accumulated deficit of $743.5 million. Because we do not generate revenue from any of our product candidates, our losses will continue as we further develop and seek regulatory approval for, and commercialize, our product candidates. As a result, our operating losses are likely to be substantial over the next several years as we continue the development of our product candidates and thereafter if none are approved or successfully launched. We are unable to predict the extent of any future losses or when we will become profitable, if at all.

Critical Accounting Estimates

Our management's discussion and analysis of our financial condition and results of operations is based on our condensed consolidated financial statements, which have been prepared in accordance with accounting principles generally accepted in the United States (U.S. GAAP). The preparation of these financial statements requires us to make estimates and assumptions that affect the reported amounts of assets, liabilities, revenues and expenses.

We evaluate our estimates and judgments 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.

Our critical accounting policies and significant estimates are detailed in our 2022 Annual Report. Our critical accounting policies and significant estimates have not changed from those previously disclosed in our 2022 Annual Report, except as discussed in the section of Note 2 to the unaudited condensed consolidated financial statements titled *Recently Adopted Accounting Standards* included in this Quarterly Report on Form 10-Q.

Results of Operations

Comparison of the Three Months Ended March 31, 2023 and 2022

Research and Development Expenses

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

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

	Three Months Ended March 31,		$ Change	% Change
	2023	2022	2023 vs. 2022	2023 vs. 2022
External expenses:				
Research and discovery	$ 2,767	$ 2,087	$ 680	33 %
3733	1,834	1,195	639	53 %
VBR	858	1,921	(1,063)	(55 %)
4334	770	1,257	(487)	(39 %)
2158	121	901	(780)	(87 %)
Total external expenses	6,350	7,361	(1,011)	(14 %)
Employee and contractor-related expenses	7,007	8,185	(1,178)	(14 %)
Facility and other expenses	1,190	1,659	(469)	(28 %)
Total research and development expenses	$ 14,547	$ 17,205	$ (2,658)	(15 %)

Research and development expenses were $14.5 million for the three months ended March 31, 2023 compared to $17.2 million for the same period in 2022. The $2.7 million decrease in research and development expenses was driven by decreases in employee and contractor-related expenses of $1.2 million due to the termination of employees as part of the reorganization announced in July 2022. We also experienced decreases in external expenses due to our discontinuation of the VBR and 2158 programs and from lower costs incurred during the three months ended March 31, 2023 compared to the same period in 2022 due to both preclinical work and start-up costs preparing for the Phase 1a trial for 4334 occurring in 2022. This was partially offset by increases in external expenses generated from the advancement of our research discovery programs and 3733.

General and Administrative Expenses

General and administrative expenses consist 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 and directors.

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

	Three Months Ended March 31,		$ Change	% Change
	2023	2022	2023 vs. 2022	2023 vs. 2022
General and administrative expenses	$ 5,012	$ 5,957	$ (945)	(16 %)

General and administrative expenses were $5.0 million for the three months ended March 31, 2023 compared to $6.0 million for the same period in 2022. The decrease of $1.0 million in general and administrative expenses was primarily due to a $0.7 million decrease in salaries and benefits because of the retirement of our former Chief Executive Officer and due to the termination of employees as part of the reorganization announced in July 2022.

Liquidity and Capital Resources

Sources of Liquidity

As a result of our significant research and development expenditures and the lack of any FDA-approved products to generate product sales revenue, we have not been profitable and have generated operating losses since we were incorporated in October 2005. We have funded our operations through March 31, 2023 principally through equity financings, raising an aggregate of $609.5 million in net proceeds, and strategic collaborations, raising an aggregate of $90.0 million through upfront payments.

Cash Flows for the Three Months Ended March 31, 2023 and 2022

The following table summarizes our cash flow activities (in thousands):

	Three Months Ended March 31,	
	2023	2022
Operating activities	$ (23,428)	$ (27,502)
Investing activities	10,000	33,049
Financing activities	4,492	—
Net (decrease) increase in cash and cash equivalents	$ (8,936)	$ 5,547

Net Cash from Operating Activities

Net cash used in operating activities was $23.4 million for the three months ended March 31, 2023. This was primarily due to our $19.0 million net loss and a decrease in other accrued expenses of $4.2 million due to payment of our 2022 annual bonuses.

Net cash used in operating activities was $27.5 million for the three months ended March 31, 2022. This was primarily due to our $23.1 million net loss and a decrease in other accrued expenses of $4.4 million due to payment of our 2021 annual bonuses.

Net Cash from Investing Activities

Net cash provided by investing activities for the three months ended March 31, 2023 was $10.0 million due to proceeds from maturities of our marketable securities.

Net cash provided by investing activities for the three months ended March 31, 2022 was $33.0 million due to proceeds from sales and maturities of our marketable securities, net of purchases.

Net Cash from Financing Activities

Net cash provided by financing activities for the three months ended March 31, 2023 was $4.5 million due to proceeds from the sale of 3,050,446 shares of our common stock under the 2020 ATM.

There were no cash flows generated from financing activities for the three months ended March 31, 2022.

Funding Requirements

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

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

We expect 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. There were no material changes in our commitments under the contractual obligations disclosed in our 2022 Annual Report. Since our inception, we have not engaged in any off-balance sheet arrangements as described in Item 303 of Regulation S-K.

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

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

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 likely 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.

Item 3. Quantitative and Qualitative Disclosures about Market Risk

Not applicable.

Item 4. Controls and Procedures

Evaluation of Disclosure Controls and Procedures

We maintain a system of disclosure controls and procedures, as defined in Rules 13a-15(e) and 15d-15(e) of the Exchange Act, that is designed to provide reasonable assurance that information that 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 the period covered by this report, we carried out an evaluation, under the supervision and with the participation of our management, including our Chief Executive Officer and President, who serves as our principal executive officer and principal financial officer, of the effectiveness of the design and operation of our disclosure controls and procedures pursuant to Exchange Act Rules 13a-15(b) and 15d-15(b) as of the end of the period covered by this report. Based upon that evaluation, our Chief Executive Officer and President concluded that our disclosure controls and procedures as of the end of the period covered by this report were effective at the reasonable assurance level.

Changes in Internal Control over Financial Reporting

There were no changes in our internal control over financial reporting in the quarter ended March 31, 2023 that materially affected, or are reasonably likely to materially affect, our internal control over financial reporting.

PART II – OTHER INFORMATION

Item 1. Legal Proceedings

We are not a party to any material legal proceedings. In the future, we may from time to time become involved in litigation relating to claims arising from our ordinary course of business.

Item 1A. Risk Factors

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

Risks Related to Our Business

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

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

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

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

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

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

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

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

We may not be successful in establishing and maintaining collaborations, which could adversely affect our ability to develop certain of our product candidates.

Developing pharmaceutical products, conducting clinical trials, obtaining regulatory approval and commercializing those products are expensive and lengthy undertakings that require significant resources and expertise. We may seek to enter into collaborations, including licensing or partnering arrangements, with other companies to support the development and commercialization of any or multiple of our programs or to obtain financing or share costs on these programs and we are currently evaluating partnering options for our CI portfolio prior to further clinical development. If we are unable to enter into collaborations on acceptable terms, if at all, we may be unable to advance certain of our product candidates through further preclinical or clinical development. We expect to face competition in seeking appropriate partners. Moreover, collaboration arrangements are complex and time consuming to negotiate, document and implement and they may require substantial resources to maintain. We may not be successful in our efforts to establish and implement collaborations or other alternative arrangements for the development of our product candidates.

If we are unable to reach agreement on favorable terms with a suitable collaboration partner for any of our product candidates, we may need to limit the number of our product candidates to advance through further preclinical or clinical development. Failure to achieve successful collaborations would limit our options for support of the development and commercialization of our programs and for financing and would likely have a material adverse impact on our business, results of operations, financial condition and share price.

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

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

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

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

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

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

- delays, suspension, or termination of clinical studies by the institutional review board or ethics committee responsible for overseeing the study at a particular study site; and
- government or other regulatory agency delays or clinical holds requiring suspension or termination of our clinical studies due to safety, tolerability or other issues related to our product candidates.

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

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

We do not have sufficient facilities or resources to conduct all of our anticipated nonclinical and clinical studies internally. As a result, we contract with CROs to conduct a significant portion of the nonclinical and clinical studies required for regulatory approval for our product candidates. Our reliance on CROs reduces our control over these activities but does not relieve us of our responsibilities. For example, we are responsible for ensuring that each of our studies is conducted in accordance with the applicable protocol, legal and regulatory requirements and scientific standards, including, in the case of clinical studies, good clinical practices, even if the study is conducted by a CRO. In the event CROs fail to perform their duties in such a fashion or we are unable to retain or continue with CROs on acceptable terms, we may be unable to complete our clinical studies and may fail to obtain regulatory approval for our product candidates.

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

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

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

- foreign taxes, including withholding of payroll taxes; and
- foreign currency fluctuations and compliance with foreign currency exchange rules, which could result in increased operating expenses and reduced revenues, and other obligations incident to doing business in another country.

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

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

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

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

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

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

- We will need to identify manufacturers for commercial supply on acceptable terms, which we may be unable to do because the number of potential manufacturers is limited, and the FDA must evaluate and approve any new or replacement contractor.
- Any third-party manufacturers with whom we contract might be unable to formulate and manufacture our product candidates in the volume and quality required to meet our clinical and, if approved, commercial needs in a timely manner.
- Any third-party manufacturers with whom we contract might not perform as agreed or might not remain in the contract manufacturing business for the time required to supply our products.
- One or more of any third-party manufacturers with whom we contract could be foreign, which increases the risk of shipping delays and adds the risk of import restrictions.

- We do not have complete control over, and cannot ensure, any third-party manufacturers' compliance with cGMP and other government regulations and corresponding foreign requirements, including periodic FDA and state regulatory inspections.
- We may be required to obtain intellectual property rights from third parties to manufacture our product candidates, and if any third-party manufacturer makes improvements in the manufacturing process for our product candidates, we may not own, or may have to share, the intellectual property rights to the innovation.
- We may be required to share our trade secrets and know-how with third parties, increasing risk of misappropriation or disclosure of our intellectual property by or to third parties.
- When contracting with third-party manufacturers, we might compete with other companies for access to these manufacturers' facilities and might be subject to manufacturing delays if the manufacturers give other clients higher priority than we are given.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Risks Related to Our Regulatory and Legal Environment

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

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

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

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

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

We, or any current or future collaborators, cannot assure you that we will receive the approvals necessary to commercialize for sale any of our product candidates, or any product candidate we acquire or develop in the future. We will need FDA approval to commercialize our product candidates in the United States and approvals from

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

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

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

We and our collaborators may be subject, directly or indirectly, to applicable U.S. federal and state anti-kickback, false claims laws, physician payment transparency laws, fraud and abuse laws or similar healthcare and security laws and regulations, and health information privacy and security laws, which could expose us or them to criminal sanctions, civil penalties, contractual damages, reputational harm and diminished profits and future earnings.

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

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

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

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

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

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

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

Our business exposes us to the risk of product liability claims that are inherent in drug development. If the use of one or more of our product candidates or approved drugs, if any, harms people, we might be subject to costly and damaging product liability claims brought against us by clinical study participants, consumers, health care providers, pharmaceutical companies or others selling our products. Our inability to obtain sufficient product liability/clinical study insurance at an acceptable cost to protect against potential product liability claims could prevent or inhibit the commercialization of pharmaceutical products we develop. We cannot predict all of the possible harms or side effects that might result and, therefore, the amount of insurance coverage we maintain might not be adequate to cover all liabilities we might incur. If we are unable to obtain insurance at an acceptable cost or otherwise protect against potential product liability claims, we will be exposed to significant liabilities, which might materially and adversely affect our business and financial position. If we are sued for any injury allegedly caused by our products, our liability could exceed our total assets and our ability to pay. Any successful product liability claims brought against us would decrease our cash and may adversely affect our business, stock price and financial condition.

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

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

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

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

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

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

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

Risks Related to Our Intellectual Property

Our business depends on protecting our intellectual property.

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

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

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

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

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

Patent and other intellectual property protection is crucial to the success of our business and prospects, and there is a substantial risk that such protections, if obtained, will prove inadequate. The legal systems of certain countries,

including China, do not always favor the enforcement of patents, trade secrets, and other intellectual property rights, particularly those relating to pharmaceutical and biotechnology products, which could make it difficult for us to stop infringement of our patents, misappropriation of our trade secrets, or marketing of competing products in violation of our proprietary rights.

Beyond the protection afforded by patents, we seek to rely on trade secret protection and confidentiality agreements to protect proprietary know-how, information, or technology that is not covered by our patents. Although our agreements require all of our employees to assign their inventions to us, and we require all of our employees, consultants, advisors, collaborators, contractors and any third parties who have access to our trade secrets, proprietary know-how and other confidential information and technology to enter into appropriate confidentiality agreements, we cannot be certain that our trade secrets, proprietary know-how and other confidential information and technology will not be subject to unauthorized disclosure or that our competitors will not otherwise gain access to or independently develop substantially equivalent trade secrets, proprietary know-how and other information and technology. If we are unable to prevent unauthorized disclosure of our intellectual property related to our product candidates and technology to third parties, we may not be able to establish or maintain a competitive advantage in our market, which could materially adversely affect our business and operations.

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

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

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

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

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

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

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

We have made, and will continue to make, certain strategic decisions in balancing the costs and the potential protections afforded by the patent laws of certain countries. As a result, we may not be able to prevent third parties

from practicing our inventions in all countries, or from selling or importing products made using our inventions in and into the United States or other countries. Third parties may use our technologies in territories in which we have not obtained patent protection to develop their own products and may infringe our patents in territories which provide inadequate enforcement mechanisms. Such third-party products may compete with our product candidates, and our patents or other intellectual property rights may not be effective or sufficient to prevent them from competing. Such competition could materially and adversely affect our business and financial condition.

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

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

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

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

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

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

In China, although the government has increased the lower and upper limits on penalties on producers of counterfeit and substandard pharmaceuticals, these penalties have not eliminated counterfeit pharmaceuticals. As a result, we may

be unable to prevent third parties from selling or purporting to sell our products in China. The existence of, and any increase in, the sales and production of counterfeit pharmaceuticals, or the technological capabilities of counterfeiters, could negatively impact our revenues, brand reputation, business and results of operations.

Risks Related to Our Common Stock

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

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

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

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

Item 2. Unregistered Sales of Equity Securities and Use of Proceeds

None.

Item 3. Defaults upon Senior Securities

None.

Item 4. Mine Safety Disclosures

Not applicable.

Item 5. Other Information

None.

Item 6. Exhibits

(a) *Exhibits.* The following exhibits are filed or furnished, as applicable, as part of this quarterly report on Form 10-Q:

Exhibit Number	Description of Document	Filed Herewith	Incorporated by Reference from	Date	Number
10.1#	Form of Notice of Stock Option Grant and Stock Option Agreement under the Amended and Restated 2014 Stock Incentive Plan.		10-K	03/22/2023	10.12
10.2#	Form of Notice of Stock Option Grant and Stock Option Agreement under the 2018 Stock Incentive Plan.		10-K	03/22/2023	10.22
31.1	Certification of Chief Executive Officer Pursuant to Section 302 of the Sarbanes-Oxley Act of 2002.	X			
32.1*	Certification of Chief Executive Officer Pursuant to Section 906 of the Sarbanes-Oxley Act of 2002.	X			
101.SCH	Inline XBRL Taxonomy Extension Schema Document.	X			
101.CAL	Inline XBRL Taxonomy Extension Calculation Linkbase Document.	X			
101.LAB	Inline XBRL Taxonomy Extension Label Linkbase Document.	X			
101.PRE	Inline XBRL Taxonomy Extension Presentation Linkbase Document.	X			
101.DEF	Inline XBRL Taxonomy Extension Definition Linkbase Document.	X			
104	Cover Page Interactive Data File (formatted as inline XBRL with applicable taxonomy extension information contained in Exhibits 101).	X			

Represents management contracts or compensatory plans or agreements.

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

In accordance with the requirements of the Securities Exchange Act of 1934, the registrant caused this report to be signed on its behalf by the undersigned, thereunto duly authorized.

Assembly Biosciences, Inc.

Date: May 4, 2023

By: /s/ Jason A. Okazaki
Jason A. Okazaki
Chief Executive Officer and President
(Principal Executive Officer and Principal Financial Officer)

EXHIBIT 31.1

CERTIFICATION

I, Jason A. Okazaki, certify that:

1. I have reviewed this Quarterly Report on Form 10-Q of Assembly Biosciences, Inc.;

2. Based on my knowledge, this report does not contain any untrue statement of a material fact or omit to state a material fact necessary to make the statements made, in light of the circumstances under which such statements were made, not misleading with respect to the period covered by this report;

3. Based on my knowledge, the financial statements, and other financial information included in this report, fairly present in all material respects the financial condition, results of operations and cash flows of the registrant as of, and for, the periods presented in this report;

4. The registrant's other certifying officer and I are responsible for establishing and maintaining disclosure controls and procedures (as defined in Exchange Act Rules 13a-15(e) and 15d-15(e)) and internal control over financial reporting (as defined in Exchange Act Rules 13a-15(f) and 15d-15(f)) for the registrant and have:

   a. Designed such disclosure controls and procedures, or caused such disclosure controls and procedures to be designed under our supervision, to ensure that material information relating to the registrant, including its consolidated subsidiaries, is made known to us by others within those entities, particularly during the period in which this report is being prepared;

   b. Designed such internal control over financial reporting, or caused such internal control over financial reporting to be designed under our supervision, 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;

   c. Evaluated the effectiveness of the registrant's disclosure controls and procedures and presented in this report our conclusions about the effectiveness of the disclosure controls and procedures, as of the end of the period covered by this report based on such evaluation; and

   d. Disclosed in this report any change in the registrant's internal control over financial reporting that occurred during the registrant's most recent fiscal quarter (the registrant's fourth fiscal quarter in the case of an annual report) that has materially affected, or is reasonably likely to materially affect, the registrant's internal control over financial reporting; and

5. The registrant's other certifying officer and I have disclosed, based on our most recent evaluation of internal control over financial reporting, to the registrant's auditors and the audit committee of the registrant's board of directors (or persons performing the equivalent functions):

   a. All significant deficiencies and material weaknesses in the design or operation of internal control over financial reporting which are reasonably likely to adversely affect the registrant's ability to record, process, summarize and report financial information; and

   b. Any fraud, whether or not material, that involves management or other employees who have a significant role in the registrant's internal control over financial reporting.

Date: May 4, 2023

By: /s/ Jason A. Okazaki
Jason A. Okazaki
Chief Executive Officer and President
(Principal Executive Officer and Principal Financial Officer)

EXHIBIT 32.1

CERTIFICATION PURSUANT TO 18 U.S.C. SECTION 1350, AS ADOPTED PURSUANT TO SECTION 906 OF THE SARBANES-OXLEY ACT OF 2002

In connection with the Quarterly Report on Form 10-Q of Assembly Biosciences, Inc. (the Company) for the period ended March 31, 2023 as filed with the Securities and Exchange Commission on or about the date hereof (the Report), I, Jason A. Okazaki, Chief Executive Officer and President, hereby certify, pursuant to 18 U.S.C. Section 1350, as adopted pursuant to Section 906 of the Sarbanes-Oxley Act of 2002, that, to my knowledge:

(1) The Report fully complies with the requirements of Section 13(a) or 15(d) of the Securities Exchange Act of 1934; and

(2) The information contained in the Report fairly presents, in all material respects, the financial condition and results of operations of the Company as of, and for, the periods presented in the Report.

/s/ Jason A. Okazaki

Jason A. Okazaki
Chief Executive Officer and President
(Principal Executive Officer and Principal Financial Officer)

Date: May 4, 2023