

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

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POST-EFFECTIVE AMENDMENT NO. 1  
TO  
FORM S-1  
REGISTRATION STATEMENT

Under  
The Securities Act of 1933

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**OPGEN, INC.**

(Exact name of registrant as specified in its charter)

**Delaware**  
(State or other jurisdiction of incorporation or  
organization)

**8071**  
(Primary Standard Industrial  
Classification Code Number)

**06-1614015**  
(I.R.S. Employer  
Identification Number)

**708 Quince Orchard Road, Suite 205**  
**Gaithersburg, MD 20878**  
**(240) 813-1260**

(Address, including zip code, and telephone number, including area code, of registrant's principal executive offices)

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**Evan Jones**  
**Chief Executive Officer**  
**708 Quince Orchard Road**  
**Gaithersburg, MD 20878**  
**(301) 869-9683**

(Name, address, including zip code, and telephone number, including area code, of agent for service)

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*Copies to:*

**Mary J. Mullany, Esq.**  
**Ballard Spahr LLP**  
**1735 Market Street**  
**51<sup>st</sup> Floor**  
**Philadelphia, PA 19103**  
**(215) 665-8500**

**Rick A. Werner, Esq.**  
**Matthew L. Fry, Esq.**  
**Haynes and Boone, LLP**  
**30 Rockefeller Plaza, 26th Floor**  
**New York, New York 10112**  
**(212) 659-7300**

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Approximate date of commencement of proposed sale to the public: As soon as practicable after the effective date of this registration statement.

If any of the securities being registered on this Form are to be offered on a delayed or continuous basis pursuant to Rule 415 under the Securities Act of 1933, as amended, check the following box. [X]

If this Form is filed to register additional securities for an offering pursuant to Rule 462(b) under the Securities Act, please check the following box and list the Securities Act registration statement number of the earlier effective registration statement for the same offering. [ ]

If this Form is a post-effective amendment filed pursuant to Rule 462(c) under the Securities Act, check the following box and list the Securities Act registration statement number of the earlier effective registration statement for the same offering. [ ]

If this Form is a post-effective amendment filed pursuant to Rule 462(d) under the Securities Act, check the following box and list the Securities Act registration statement number of the earlier effective registration statement for the same offering. [X] (File No. 333-233775)

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, or a smaller reporting 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 [ ]

Non-Accelerated Filer [X]

Accelerated Filer [ ]

Smaller Reporting Company [X]

Emerging Growth Company [X]

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 to Section 7(a)(2)(B) of the Securities Act. [ ]

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**This post-effective amendment shall become effective upon filing with the Securities and Exchange Commission in accordance with Rule 462(d) under the Securities Act of 1933, as amended.**

## EXPLANATORY NOTE

This Post-Effective Amendment No. 1 (this "Amendment") relates to the Registrant's Registration Statement on Form S-1 (File No. 333-233775), as amended, declared effective on October 23, 2019 by the Securities and Exchange Commission. The Registrant is filing this Amendment for the sole purpose of replacing Exhibit 5.1 to the Registration Statement. This Amendment does not modify any provision of Part I or Part II of the Registration Statement other than Item 16(a) of Part II as set forth below.

## PART II

### Information Not Required in Prospectus

#### Item 16. Exhibits and Financial Statement Schedules.

(a) Exhibits:

#### EXHIBIT INDEX

| <b>Exhibit Number</b> | <b>Description</b>   |
|-----------------------|--|
| 1.1                   | <a href="#"><u>Form of Underwriting Agreement (incorporated by reference to Exhibit 1.1 to the Registrant's Registration Statement on Form S-1, Amendment No. 1, File No. 333-233775, filed on October 15, 2019)</u></a>   |
| 2.1                   | <a href="#"><u>Implementation Agreement, dated as of September 4, 2019, by and among Curetis N.V., as Seller, and Crystal GmbH, as Purchaser and OpGen, Inc. (incorporated by reference to Exhibit 2.1 to the Registrant's Current Report on Form 8-K, filed on September 4, 2019)</u></a> ^   |
| 3.1                   | <a href="#"><u>Amended and Restated Certificate of Incorporation of the Registrant (incorporated by reference to Exhibit 3.1 of the Registrant's Current Report on Form 8-K, File No. 001-37367, filed on May 13, 2015)</u></a> ^  |
| 3.2                   | <a href="#"><u>Certificate of Correction to Amended and Restated Certificate of Incorporation of the Registrant, dated June 6, 2016 (incorporated by reference to Exhibit 3.1 of the Registrant's Current Report on Form 8-K, filed on June 6, 2016)</u></a> ^   |
| 3.3                   | <a href="#"><u>Certificate of Amendment to the Amended and Restated Certificate of Incorporation of the Registrant dated and filed with the Delaware Secretary of State on January 17, 2018 (incorporated by reference to Exhibit 3.1 to the Registrant's Current Report on Form 8-K filed on January 17, 2018)</u></a> ^            |
| 3.4                   | <a href="#"><u>Certificate of Amendment to the Amended and Restated Certificate of Incorporation, as amended, of the Registrant dated and filed with the Delaware Secretary of State on August 28, 2019 (incorporated by reference to Exhibit 3.1 to the Registrant's Current Report on Form 8-K filed on August 28, 2019)</u></a> ^ |
| 3.5                   | <a href="#"><u>Amended and Restated Bylaws of the Registrant (incorporated by reference to Exhibit 3.2 to the Registrant's Form S-1, File No. 333-202478, filed on March 3, 2015)</u></a>  |

- 4.1 [Form of Common Stock Certificate of the Registrant \(incorporated by reference to Exhibit 4.1 to the Registrant's Annual Report on Form 10-K for the year ended December 31, 2018, filed on February 27, 2019\) ^](#)
- 4.2 [Form of Offered Warrant to Purchase Common Stock \(IPO Warrant\) \(incorporated by reference to Exhibit 4.8 of the Registrant's Form S-1/A, File No. 333-202478, filed on March 20, 2015\)](#)
- 4.3 [Form of Warrant to Purchase Common Stock \(issued to jVen Capital, LLC and Merck Global Health Innovation Fund\) \(incorporated by reference to Exhibit 4.1 to the Registrant's Current Report on Form 8-K Amendment No. 2, filed on July 10, 2017\) ^](#)
- 4.4 [Form of Common Stock Purchase Warrant for February 2018 Public Offering \(incorporated by reference to Exhibit 4.3 to the Registrant's Form S-1/A, File No. 333-222140, filed on January 31, 2018\)](#)
- 4.5 [Form of Pre-Funded Common Stock Purchase Warrant for February 2018 Public Offering \(incorporated by reference to Exhibit 4.4 to the Registrant's Form S-1/A, File No. 333-222140, filed on January 31, 2018\)](#)
- 4.6 [Form of Placement Agent Warrant for February 2018 Public Offering \(incorporated by reference to Exhibit 4.5 to the Registrant's Form S-1/A, File No. 333-222140, filed on January 31, 2018\)](#)
- 4.7 [Form of Common Stock Purchase Warrant for July 2017 Public Offering \(incorporated by reference to Exhibit 4.4 to the Registrant's Form S-1, Amendment No. 2, File No. 333-218392, filed on July 11, 2017\)](#)
- 4.8 [Form of Placement Agent Warrant for July 2017 Public Offering \(incorporated by reference to Exhibit 4.5 to the Registrant's Form S-1, File No. 333-218392, filed on July 11, 2017\)](#)
- 4.9 [Form of Pre-funded Warrant \(incorporated by reference to Exhibit 4.9 to the Registrant's Registration Statement on Form S-1, Amendment No. 1, File No. 333-233775, filed on October 15, 2019\)](#)
- 4.10 [Form of Underwriter's Warrant \(incorporated by reference to Exhibit 4.10 to the Registrant's Registration Statement on Form S-1, Amendment No. 1, File No. 333-233775, filed on October 15, 2019\)](#)
- 4.11 [Form of Common Stock Purchase Warrant \(incorporated by reference to Exhibit 4.11 to the Registrant's Registration Statement on Form S-1, Amendment No. 1, File No. 333-233775, filed on October 15, 2019\)](#)
- 5.1\* [Opinion of Ballard Spahr LLP](#)
- 10.1 [Lease Agreement, dated as of June 30, 2008, between the Registrant and ARE-708 Quince Orchard, LLC \(the "Landlord"\) \(incorporated by reference to Exhibit 10.1 of Form S-1/A, file No. 333-202478, filed March 3, 2015\)](#)
- 10.1.1 [First Amendment to Lease, dated as of April 4, 2011, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.1.1 of Form S-1, File No. 333-202478, filed March 3, 2015\)](#)
- 10.1.2 [Second Amendment to Lease Agreement, dated as of August 15, 2012, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.1.2 of Form S-1, File No. 333-202478, filed March 3, 2015\)](#)
- 10.1.3 [Third Amendment to Lease, dated as of December 30, 2013, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.1.3 of Form S-1, File No. 333-202478, filed March 3, 2015\)](#)
- 10.1.4 [Fourth Amendment to Lease Agreement, dated as of March 21, 2014, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.4 of Form S-1, File No. 333-202478, filed March 3, 2015\)](#)
- 10.1.5 [Fifth Amendment to Lease Agreement, dated as of March 20, 2015, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.1.5 of Form S-1, Amendment No. 1, File No. 333-202478, filed on March 20, 2015\)](#)
- 10.1.6 [Sixth Amendment to Lease Agreement \(and Amendment to Reimbursement Agreement\), dated as of April 30, 2015, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.1.6 of Form S-1, Amendment No. 8, File No. 333-202478, filed on May 1, 2015\)](#)
- 10.1.7 [Seventh Amendment to Lease Agreement, dated as of June 30, 2015, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.1 of Current Report on Form 8-K, filed on July 7, 2015\) ^](#)

- 10.1.8 [Eighth Amendment to Lease Agreement, dated September 8, 2015, between the Registrant and the Landlord \(incorporated by reference to Exhibit 10.6 of Quarterly Report on Form 10-Q, filed on November 13, 2015\)](#) ^
- 10.2 [Lease Extension #6, dated October 14, 2016, by and between the Registrant and Cummings Properties, LLC \(related to AdvanDx facility\)\(incorporated by reference to Exhibit 10.2 of Quarterly Report on Form 10-Q, filed November 14, 2016\)](#) ^
- 10.3 [Form of Indemnification Agreement between the Registrant and each of its directors and executive officers \(incorporated by reference to Exhibit 10.2 of Form S-1, File No. 333-202478, filed on March 3, 2015\)](#)
- 10.4 [2015 Equity Incentive Plan, as amended and restated on March 29, 2018 \(incorporated by reference to Exhibit 10.4 to the Registrant's Annual Report on Form 10-K for the year ended December 31, 2017, filed on March 29, 2018\)](#) ^
- 10.5 ! [Non-Employee Director Compensation Policy \(incorporated by reference to the Registrant's Registration Statement on Form S-1, SEC File No. 333-233775, filed on September 16, 2019\)](#)
- 10.6 [Warrant Agreement, dated as of May 8, 2015, between the Registrant and Philadelphia Stock Transfer, Inc., as warrant agent \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on May 13, 2015\)](#) ^
- 10.7.1 ! [Form of Stock Option Agreement under the 2015 Equity Incentive Plan for employees and consultants \(incorporated by reference to Exhibit 10.9.1 to the Registrant's Annual Report on Form 10-K for the year ended December 31, 2016, filed on March 24, 2017\)](#) ^
- 10.7.2 ! [Form of Stock Option Agreement under the 2015 Equity Incentive Plan for non-employee directors \(initial grant\) \(incorporated by reference to Exhibit 10.9.2 to the Registrant's Annual Report on Form 10-K for the year ended December 31, 2016, filed on March 24, 2017\)](#) ^
- 10.7.3 ! [Form of Stock Option Agreement under the 2015 Equity Incentive Plan for non-employee directors \(annual grant\) \(incorporated by reference to Exhibit 10.9.3 to the Registrant's Annual Report on Form 10-K for the year ended December 31, 2016, filed on March 24, 2017\)](#) ^
- 10.8 ! [Form of Restricted Stock Unit Award Agreement under 2015 Equity Incentive Plan \(incorporated by reference to Exhibit 10.10 to the Registrant's Annual Report on Form 10-K for the year ended December 31, 2016, filed March 24, 2017\)](#) ^
- 10.9 [Common Stock and Note Purchase Agreement, dated as of July 14, 2015, between the Registrant and Merck Global Health Innovation Fund, LLC \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on July 16, 2015\)](#) ^
- 10.10 [Senior Secured Promissory Note, dated as of July 14, 2015, between the Registrant and Merck Global Health Innovation Fund, LLC \(incorporated by reference to Exhibit 10.2 to the Registrant's Current Report on Form 8-K, filed on July 16, 2015\)](#) ^
- 10.10.1 [Second Amended & Restated Senior Secured Promissory Note, dated June 28, 2017, by and between the Registrant and Merck Global Health Innovation Fund, LLC \(incorporated by reference to Exhibit 10.3 to the Registrant's Current Report on Form 8-K, Amendment No. 1, filed on June 28, 2017\)](#) ^
- 10.10.2 [Allonge, dated June 11, 2018, to the Second Amended and Restated Senior Secured Promissory Note, dated June 28, 2017, with a principal amount of \\$1,000,000 issued by OpGen, Inc. to Merck Global Health Innovation Fund, LLC \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on June 11, 2018\)](#) ^
- 10.11 [Third Amended and Restated Investors' Rights Agreement, dated as of December 18, 2013, among the Registrant and, certain investors \(registration rights provisions\) \(incorporated by reference to Exhibit 4.2 to the Registrant's Form S-1, File No. 333-202478, filed on March 3, 2015\)](#)

- 10.12 [Registration Rights Agreement, dated as of July 14, 2015, among the Registrant, Merck Global Health Innovation Fund, LLC, SLS Invest AB and LD Pensions \(incorporated by reference to Exhibit 10.3 to the Registrant's Current Report on Form 8-K, filed on July 16, 2015\)](#) ^
- 10.13 [Letter Agreement, dated July 12, 2015, between the Registrant and Fluidigm Corporation \(incorporated by reference to Exhibit 10.5 to the Registrant's Quarterly Report on Form 10-Q for the quarter ended June 30, 2015, filed on August 14, 2015\)](#) ^
- 10.14 [Securities Purchase Agreement, dated as of May 12, 2016, by and between the Registrant and the Purchasers party thereto \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on May 17, 2016\)](#) ^
- 10.15 [Amended and Restated Securities Purchase Agreement, dated as of May 18, 2016, by and between the Registrant and the Purchasers party thereto \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on May 20, 2016\)](#) ^
- 10.16 ! [Stock Option Award Agreement, dated April 28, 2016, by and between the Registrant and Evan Jones \(incorporated by reference to Exhibit 10.5 to the Registrant's Quarterly Report on Form 10-Q for the quarter ended June 30, 2016, filed on August 11, 2016\)](#) ^
- 10.17 [Common Stock Sales Agreement, dated September 13, 2016, by and between the Registrant and Cowen and Company, LLC \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on September 14, 2016\)](#) ^
- 10.18 [Amended & Restated Note Purchase Agreement, dated as of July 10, 2017, by and between the Registrant and jVen Capital, LLC \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, Amendment No. 2, filed on July 10, 2017\)](#) ^
- 10.19 [Form of Secured Convertible Promissory Note #1 to be issued to jVen Capital, LLC \(incorporated by reference to Exhibit 10.2 to the Registrant's Current Report on Form 8-K/A, filed on July 10, 2017\)](#) ^
- 10.20 [Form of Secured Promissory Note #2 and #3 to be issued to jVen Capital, LLC \(incorporated by reference to Exhibit 10.3 to the Registrant's Current Report on Form 8-K/A, filed on July 10, 2017\)](#) ^
- 10.21 [Amended and Restated Registration Rights Agreement, dated as of June 6, 2017, by and between the Registrant and the Investors party thereto \(incorporated by reference to Exhibit 10.3 to the Registrant's Current Report on Form 8-K, filed on June 6, 2017\)](#) ^
- 10.22± [Supply Agreement, dated as of June 15, 2017, by and between the Registrant and Life Technologies Corporation \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on June 19, 2017\)](#) ^
- 10.23 [Securities Purchase Agreement, dated as of July 12, 2017, among the Registrant and the purchasers signatory thereto, \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on July 14, 2017\)](#) ^
- 10.24 [Engagement Letter with H.C Wainwright & Co., dated as of June 12, 2017 \(incorporated by reference to Exhibit 1.2 to the Registrant's Registration Statement on Form S-1, Amendment No. 2, File No. 333-218392, filed on July 11, 2017\)](#)
- 10.25 ! [Executive Change In Control and Severance Benefits Agreement, dated September 24, 2018 between OpGen, Inc. and Evan Jones \(incorporated by reference to Exhibit 10.2 to the Registrant's Current Report on Form 8-K, filed on September 25, 2018\)](#) ^
- 10.26 ! [Executive Change In Control and Severance Benefits Agreement, dated September 24, 2018 between OpGen, Inc. and Timothy C. Dec \(incorporated by reference to Exhibit 10.3 to the Registrant's Current Report on Form 8-K, filed on September 25, 2018\)](#) ^
- 10.27 ! [Executive Change In Control and Severance Benefits Agreement, dated September 24, 2018 between OpGen, Inc. and Vadim Sapiro \(incorporated by reference to Exhibit 10.4 to the Registrant's Current Report on Form 8-K, filed on September 25, 2018\)](#) ^

- 10.28 [Form of Securities Purchase Agreement between the Registrant and the purchasers signatory thereto \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on February 2, 2018\)](#) ^
- 10.29 [Engagement Letter, dated as of December 18, 2017, between the Registrant and H.C. Wainwright & Co., LLC \(incorporated by reference to Exhibit 1.2 to the Registrant's Registration Statement on Form S-1, Amendment No. 1, File No. 333-222140, filed on January 31, 2018\)](#)
- 10.30 ! [OpGen, Inc. Retention Plan for Executives \(incorporated by reference to Exhibit 10.1 to the Registrant's Current Report on Form 8-K, filed on September 25, 2018\)](#) ^
- 21.1 [Subsidiaries of the Registrant \(incorporated by reference to Exhibit 21.1 to the Registrant's Annual Report on Form 10-K for the year ended December 31, 2018, filed on February 27, 2019\)](#) ^
- 23.1 [Consent of CohnReznick LLP \(incorporated by reference to Exhibit 23.1 to the Registrant's Registration Statement on Form S-1, Amendment No. 2, File No. 333-233775, filed on October 17, 2019\)](#)
- 23.2 [Consent of PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft \(incorporated by reference to Exhibit 23.2 to the Registrant's Registration Statement on Form S-1, Amendment No. 2, File No. 333-233775, filed on October 17, 2019\)](#)
- 23.3 \* [Consent of Ballard Spahr LLP \(included in Exhibit 5.1\)](#)
- 24.1 [Power of attorney \(included on signature page to the Registrant's Registration Statement on Form S-1, SEC File No. 333-233775 filed on September 16, 2019\)](#)
- 99.1 [Consent of Oliver Schacht, Ph.D. \(incorporated by reference to Exhibit 99.1 to the Registrant's Registration Statement on Form S-1, Amendment No. 2, File No. 333-233775, filed on October 17, 2019\)](#)
- 99.2 [Consent of William Rhodes \(incorporated by reference to Exhibit 99.2 to the Registrant's Registration Statement on Form S-1, Amendment No. 2, File No. 333-233775, filed on October 17, 2019\)](#)

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\* Filed herewith

! Denotes management compensation plan or contract

± Confidential treatment has been requested for certain portions of this agreement pursuant to an application for confidential treatment filed with the Securities and Exchange Commission on June 19, 2017. Such provisions have been filed separately with the Commission.

^ SEC File No. 001-37367

(b) Financial Statements Schedules:

Schedules have been omitted because the information required to be set forth therein is not applicable or is shown in the financial statements or notes thereto.



## SIGNATURES

Pursuant to the requirements of the Securities Act of 1933, the registrant has duly caused this Post-Effective Amendment No. 1 to the Registration Statement on Form S-1 to be signed on its behalf by the undersigned, thereunto duly authorized, in the City of Gaithersburg, State of Maryland, on October 25, 2019.

### OPGEN, INC.

By: /s/ Evan Jones  
Evan Jones  
Chief Executive Officer

### POWER OF ATTORNEY

Pursuant to the requirements of the Securities Act of 1933, as amended, this Post-Effective Amendment No. 1 to the Registration Statement has been signed by the following persons in the capacities and on the date indicated.

| Signature   | Title  | Date             |
|---|--|------------------|
| <u>/s/ Evan Jones</u><br>Evan Jones                               | Chief Executive Officer and Director (principal executive officer)                     | October 25, 2019 |
| <u>/s/ Timothy C. Dec</u><br>Timothy C. Dec                       | Chief Financial Officer (principal financial officer and principal accounting officer) | October 25, 2019 |
| <u>*</u><br>R. Donald Elsey                                       | Director   | October 25, 2019 |
| <u>*</u><br>Tina S. Nova  | Director   | October 25, 2019 |
| <u>*</u><br>Misti Ushio   | Director   | October 25, 2019 |
| <u>*/s/ Timothy C. Dec</u><br>Timothy C. Dec, as attorney in fact |  | October 25, 2019 |



# Ballard Spahr LLP

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1735 Market Street, 51st Floor  
Philadelphia, PA 19103-7599  
TEL 215.665.8500  
FAX 215.864.8999  
www.ballardspahr.com

October 25, 2019

OpGen, Inc.  
708 Quince Orchard Road  
Suite 205  
Gaithersburg, Maryland 20878

RE: OpGen, Inc. Form S-1 Registration Statement

Ladies and Gentlemen:

We have acted as counsel to OpGen, Inc., a Delaware corporation (the "Company"), in connection with the preparation of a Registration Statement on Form S-1 (Registration No. 333-233775) (the "Registration Statement") filed by the Company with the U.S. Securities and Exchange Commission (the "Commission") under the Securities Act of 1933, as amended (the "Securities Act"), on September 16, 2019, as amended on October 15, 2019 and October 17, 2019, with respect to the offer and sale of (i) 2,590,170 firm units (the "Units"), each Unit consisting of one share of Common Stock of the Company, \$0.01 par value per share (the "Common Stock") and one warrant to purchase one share of Common Stock (each, a "Common Warrant" and collectively, the "Common Warrants"), (ii) 2,109,830 pre-funded units (the "Firm Pre-Funded Units"), the "Pre-Funded Units"), each Pre-Funded Unit consisting of one pre-funded warrant to purchase one share of Common Stock (each a "Pre-Funded Warrant" and collectively, the "Pre-Funded Warrants") and one Common Warrant, (iii) up to 705,000 shares of Common Stock and/or Common Warrants subject to an over-allotment option granted to the Underwriter (the "Option Securities"), and (iv) warrants to purchase 235,000 shares of Common Stock, or 270,250 shares of Common Stock if the Underwriter exercises its over-allotment option in full (the "HCW Warrants"), to be issued to H.C. Wainwright & Co., LLC (the "Underwriter") as compensation for its services pursuant to that certain Underwriting Agreement, dated October 23, 2019, by and between the Company and the Underwriter (the "Underwriting Agreement"). The HCW Warrants, the Common Warrants included in the Option Securities, the Common Warrants and the Pre-Funded Warrants are collectively referred to herein as the "Warrants," and the Units, Pre-Funded Units, the shares of Common Stock included in the Units, the shares of Common Stock included in the Option Securities, the shares of Common Stock underlying the HCW Warrants, the shares of Common Stock underlying the Common Warrants and the shares of Common Stock underlying the Pre-Funded Warrants are collectively referred to herein as the "Securities."

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The Securities are to be sold by the Company pursuant to a prospectus to be filed with the Registration Statement (the "Prospectus"), the Warrants and the Underwriting Agreement.

We have examined originals or copies (certified or otherwise identified to our satisfaction) of (i) the Amended and Restated Certificate of Incorporation of the Company together with all amendments thereto; (ii) the Certificate of Correction to the Amended and Restated Certificate of Incorporation; (iii) the Certificate of Designation of Preferences, Rights and Limitations of Series B Convertible Preferred Stock; (iv) the Amended and Restated Bylaws of the Company; (v) the Registration Statement and the exhibits thereto; (vi) the Prospectus; (vii) the Underwriting Agreement; (viii) such other corporate records, agreements, documents and instruments; and (ix) such certificates or comparable documents of public officials and other sources, believed by us to be reliable, and of officers and representatives of the Company, and have made such inquiries of such officers and representatives, as we have deemed relevant and necessary as a basis for the opinions hereinafter set forth.

In such examination, we have assumed the genuineness of all signatures, the legal capacity of all natural persons, the authenticity of all documents submitted to us as originals, the conformity to original documents of all documents submitted to us as certified, conformed or photostatic copies and the authenticity of the originals of such latter documents. As to all questions of fact material to this opinion that have not been independently established, we have relied upon certificates or comparable documents of officers and representatives of the Company.

Based upon the foregoing, and subject to the qualifications, assumptions and limitations set forth herein, we are of the opinion that (i) the Securities are or will be, upon issuance, duly authorized, and, when issued and sold in accordance with the terms and conditions of the Underwriting Agreement, the Warrants and the Prospectus, as applicable, will be validly issued, fully paid and non-assessable and (ii) provided that the Warrants have been duly executed and delivered by the Company and duly delivered to the purchasers thereof, the Warrants, when issued and sold as contemplated in the Underwriting Agreement, the Registration Statement and the Prospectus in exchange for the requisite payment therefor, will be valid and legally binding obligations of the Company.

Our opinion is limited to the laws of the State of Delaware, the laws of the State of New York and the United States federal laws, and we express no opinion with respect to the laws of any other jurisdiction. No opinion is expressed herein with respect to the qualification of the Securities under the securities or blue sky laws of any state or any foreign jurisdiction.

We hereby consent to the filing of this opinion with the Commission as an exhibit to the Registration Statement in accordance with the requirements of Item 601(b)(5) of Regulation S-K promulgated under the Securities Act, and to the use of this firm's name therein and in the Prospectus under the caption "Legal Matters." In giving this consent, we do not admit that we are within the category of persons whose consent is required by Section 7 of the Securities Act and the rules and regulations promulgated thereunder.

Sincerely yours,

/s/ Ballard Spahr LLP