


# Stanford

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## Noah Greenwald

Ph.D. Student in Cancer Biology, admitted Autumn 2017

 Curriculum Vitae available Online

### Bio

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#### BIO

PhD Candidate in the Cancer Biology program. Joint member of the Angelo and Curtis labs working to integrate imaging and sequencing data to better understand the tumor microenvironment in breast cancer.

#### LINKS

- My website: <https://ngreenwald.github.io/>
- Angelo Lab: <https://www.angelolab.com/>
- Curtis Lab: <https://med.stanford.edu/curtislab.html>

### Research & Scholarship

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#### CURRENT RESEARCH AND SCHOLARLY INTERESTS

Using deep learning to analyze multiplexed imaging data; profiling the tumor microenvironment to predict response and resistance to checkpoint blockade; integrating genomics, transcriptomics, and imaging to understand how changes in DNA and RNA affect phenotypes at the protein level

### Publications

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#### PUBLICATIONS

- **Whole-cell segmentation of tissue images with human-level performance using large-scale data annotation and deep learning.** *Nature biotechnology*  
Greenwald, N. F., Miller, G., Moen, E., Kong, A., Kagel, A., Dougherty, T., Fullaway, C. C., McIntosh, B. J., Leow, K. X., Schwartz, M. S., Pavelchek, C., Cui, S., Campilsson, et al  
2021
- **Single-Cell Imaging Maps Inflammatory Cell Subsets to Pulmonary Arterial Hypertension Vasculopathy.** *American journal of respiratory and critical care medicine*  
Ferrian, S., Cao, A., McCaffrey, E. F., Saito, T., Greenwald, N. F., Nicolls, M. R., Bruce, T., Zamanian, R. T., Del Rosario, P., Rabinovitch, M., Angelo, M.  
2023
- **Robust phenotyping of highly multiplexed tissue imaging data using pixel-level clustering.** *Nature communications*  
Liu, C. C., Greenwald, N. F., Kong, A., McCaffrey, E. F., Leow, K. X., Mrdjen, D., Cannon, B. J., Rumberger, J. L., Varra, S. R., Angelo, M.  
2023; 14 (1): 4618
- **Advances and prospects for the Human BioMolecular Atlas Program (HuBMAP).** *Nature cell biology*  
Jain, S., Pei, L., Spraggins, J. M., Angelo, M., Carson, J. P., Gehlenborg, N., Ginty, F., Gonçalves, J. P., Hagood, J. S., Hickey, J. W., Kelleher, N. L., Laurent, L. C., Lin, et al  
2023

- **Expanded vacuum-stable gels for multiplexed high-resolution spatial histopathology.** *Nature communications*  
Bai, Y., Zhu, B., Oliveria, J., Cannon, B. J., Feyaerts, D., Bosse, M., Vijayaragavan, K., Greenwald, N. F., Phillips, D., Schurch, C. M., Naik, S. M., Ganio, E. A., Gaudilliere, et al  
2023; 14 (1): 4013
- **A spatially resolved timeline of the human maternal-fetal interface.** *Nature*  
Greenbaum, S., Averbukh, I., Soon, E., Rizzuto, G., Baranski, A., Greenwald, N. F., Kagel, A., Bosse, M., Jaswa, E. G., Khair, Z., Kwok, S., Warshawsky, S., Piyadasa, et al  
2023; 619 (7970): 595-605
- **CLINICAL RESPONSE TO THE PDGFRA/KIT INHIBITOR AVAPRITINIB IN PEDIATRIC AND YOUNG ADULT HIGH-GRADE GLIOMA PATIENTS WITH H3K27M OR PDGFRA GENOMIC ALTERATIONS**  
Trissal, M., Mayr, L., Schwark, K., LaBelle, J., Kong, S., Furtner, J., Weiler-Wichtl, L., Supko, J., Rozowsky, J., Hack, O., Groves, A., Marques, J., Leiss, et al  
OXFORD UNIV PRESS INC.2023
- **Single-cell spatial proteomic imaging for human neuropathology.** *Acta neuropathologica communications*  
Vijayaragavan, K., Cannon, B. J., Tebaykin, D., Bosse, M., Baranski, A., Oliveria, J. P., Bukhari, S. A., Mrdjen, D., Corces, M. R., McCaffrey, E. F., Greenwald, N. F., Sigal, Y., Marquez, et al  
2022; 10 (1): 158
- **Spatial epitope barcoding reveals clonal tumor patch behaviors.** *Cancer cell*  
Rovira-Clave, X., Drainas, A. P., Jiang, S., Bai, Y., Baron, M., Zhu, B., Dallas, A. E., Lee, M. C., Chu, T. P., Holzem, A., Ayyagari, R., Bhattacharya, D., McCaffrey, et al  
2022
- **Structural variants shape driver combinations and outcomes in pediatric high-grade glioma** *NATURE CANCER*  
Dubois, F. B., Shapira, O., Greenwald, N. F., Zack, T., Wala, J., Tsai, J. W., Crane, A., Baguette, A., Hadjadj, D., Harutyunyan, A. S., Kumar, K. H., Blattner-Johnson, M., Vogelzang, et al  
2022
- **Combined protein and nucleic acid imaging reveals virus-dependent B cell and macrophage immunosuppression of tissue microenvironments.** *Immunity*  
Jiang, S., Chan, C. N., Rovira-Clave, X., Chen, H., Bai, Y., Zhu, B., McCaffrey, E., Greenwald, N. F., Liu, C., Barlow, G. L., Weirather, J. L., Oliveria, J. P., Nakayama, et al  
2022
- **Deep Learning-Inferred Multiplex ImmunoFluorescence for Immunohistochemical Image Quantification.** *Nature machine intelligence*  
Ghahremani, P., Li, Y., Kaufman, A., Vanguri, R., Greenwald, N., Angelo, M., Hollmann, T. J., Nadeem, S.  
2022; 4 (4): 401-412
- **PPM1D mutations are oncogenic drivers of de novo diffuse midline glioma formation.** *Nature communications*  
Khadka, P., Reitman, Z. J., Lu, S., Buchan, G., Gionet, G., Dubois, F., Carvalho, D. M., Shih, J., Zhang, S., Greenwald, N. F., Zack, T., Shapira, O., Pelton, et al  
1800; 13 (1): 604
- **Transition to invasive breast cancer is associated with progressive changes in the structure and composition of tumor stroma.** *Cell*  
Risom, T., Glass, D. R., Averbukh, I., Liu, C. C., Baranski, A., Kagel, A., McCaffrey, E. F., Greenwald, N. F., Rivero-Gutiérrez, B., Strand, S. H., Varma, S., Kong, A., Keren, et al  
2022; 185 (2): 299-310.e18
- **The immunoregulatory landscape of human tuberculosis granulomas.** *Nature immunology*  
McCaffrey, E. F., Donato, M., Keren, L., Chen, Z., Delmastro, A., Fitzpatrick, M. B., Gupta, S., Greenwald, N. F., Baranski, A., Graf, W., Kumar, R., Bosse, M., Fullaway, et al  
2022
- **Multiplexed Ion Beam Imaging: Insights into Pathobiology.** *Annual review of pathology*  
Liu, C. C., McCaffrey, E. F., Greenwald, N. F., Soon, E., Risom, T., Vijayaragavan, K., Oliveria, J., Mrdjen, D., Bosse, M., Tebaykin, D., Bendall, S. C., Angelo, M.  
2021
- **Single cell biology-a Keystone Symposia report.** *Annals of the New York Academy of Sciences*  
Cable, J., Elowitz, M. B., Domingos, A. I., Habib, N., Itzkovitz, S., Hamidzada, H., Balzer, M. S., Yanai, I., Liberali, P., Whited, J., Streets, A., Cai, L., Stergachis, et al

2021

- **DeepCell Kiosk: scaling deep learning-enabled cellular image analysis with Kubernetes.** *Nature methods*  
Bannon, D., Moen, E., Schwartz, M., Borba, E., Kudo, T., Greenwald, N., Vijayakumar, V., Chang, B., Pao, E., Osterman, E., Graf, W., Van Valen, D.  
2021; 18 (1): 43–45
- **A Molecularly Integrated Grade for Meningioma.** *Neuro-oncology*  
Driver, J., Hoffman, S. E., Tavakol, S., Woodward, E., Maury, E. A., Bhave, V., Greenwald, N. F., Nassiri, F., Aldape, K., Zadeh, G., Choudhury, A., Vasudevan, H. N., Magill, et al  
2021
- **Evaluation of Geuenich et al.: Targeting a crucial bottleneck for analyzing single-cell multiplexed imaging data.** *Cell systems*  
Averbukh, I., Greenwald, N. F., Liu, C. C., Angelo, M.  
2021; 12 (12): 1121-1123
- **Single-cell metabolic profiling of human cytotoxic T cells.** *Nature biotechnology*  
Hartmann, F. J., Mrdjen, D. n., McCaffrey, E. n., Glass, D. R., Greenwald, N. F., Bharadwaj, A. n., Khair, Z. n., Verberk, S. G., Baranski, A. n., Baskar, R. n., Graf, W. n., Van Valen, D. n., Van den Bossche, et al  
2020
- **The Society for Immunotherapy in Cancer statement on best practices for multiplex immunohistochemistry (IHC) and immunofluorescence (IF) staining and validation.** *Journal for immunotherapy of cancer*  
Taube, J. M., Akturk, G. n., Angelo, M. n., Engle, E. L., Gnjjatic, S. n., Greenbaum, S. n., Greenwald, N. F., Hedvat, C. V., Hollmann, T. J., Juco, J. n., Parra, E. R., Rebelatto, M. C., Rimm, et al  
2020; 8 (1)
- **Large expert-curated database for benchmarking document similarity detection in biomedical literature search** *DATABASE-THE JOURNAL OF BIOLOGICAL DATABASES AND CURATION*  
Brown, P., Tan, A., El-Esawi, M. A., Liehr, T., Blanck, O., Gladue, D. P., Almeida, G. F., Cernava, T., Sorzano, C. O., Yeung, A. K., Engel, M. S., Chandrasekaran, A., Muth, et al  
2019
- **MIBI-TOF: A multiplexed imaging platform relates cellular phenotypes and tissue structure.** *Science advances*  
Keren, L., Bosse, M., Thompson, S., Risom, T., Vijayaragavan, K., McCaffrey, E., Marquez, D., Angoshtari, R., Greenwald, N. F., Fienberg, H., Wang, J., Kambham, N., Kirkwood, et al  
2019; 5 (10): eaax5851
- **Neuronal differentiation and cell-cycle programs mediate response to BET-bromodomain inhibition in MYC-driven medulloblastoma** *NATURE COMMUNICATIONS*  
Bandopadhyay, P., Piccioni, F., O'Rourke, R., Ho, P., Gonzalez, E. M., Buchan, G., Qian, K., Gionet, G., Girard, E., Coxon, M., Rees, M. G., Brenan, L., Dubois, et al  
2019; 10: 2400
- **SvABA: genome-wide detection of structural variants and indels by local assembly** *GENOME RESEARCH*  
Wala, J. A., Bandopadhyay, P., Greenwald, N. F., O'Rourke, R., Sharpe, T., Stewart, C., Schumacher, S., Li, Y., Weischenfeldt, J., Yao, X., Nusbaum, C., Campbell, P., Getz, et al  
2018; 28 (4): 581–91
- **Radiographic prediction of meningioma grade by semantic and radiomic features** *PLOS ONE*  
Coroller, T. P., Bi, W., Huynh, E., Abedalthagafi, M., Aizer, A. A., Greenwald, N. F., Parmar, C., Narayan, V., Wu, W. W., de Moura, S., Gupta, S., Beroukhim, R., Wen, et al  
2017; 12 (11): e0187908
- **Patient-derived xenografts undergo mouse-specific tumor evolution** *NATURE GENETICS*  
Ben-David, U., Ha, G., Tseng, Y., Greenwald, N. F., Oh, C., Shih, J., McFarland, J. M., Wong, B., Boehm, J. S., Beroukhim, R., Golub, T. R.  
2017; 49 (11): 1567–+
- **Osteoglycin promotes meningioma development through downregulation of NF2 and activation of mTOR signaling** *CELL COMMUNICATION AND SIGNALING*  
Mei, Y., Du, Z., Hu, C., Greenwald, N. F., Abedalthagafi, M., Agar, N. R., Dunn, G. P., Bi, W., Santagata, S., Dunn, I. F.  
2017; 15: 34

- **Artificial intelligence in research** *SCIENCE*  
Musib, M.  
2017; 357 (6346): 28
- **Clinical Identification of Oncogenic Drivers and Copy-Number Alterations in Pituitary Tumors** *ENDOCRINOLOGY*  
Bi, W., Greenwald, N. F., Ramkissoon, S. H., Abedalthagafi, M., Coy, S. M., Ligon, K. L., Mei, Y., MacConaill, L., Ducar, M., Min, L., Santagata, S., Kaiser, U. B., Beroukhi, et al  
2017; 158 (7): 2284–91
- **Clinical targeted exome-based sequencing in combination with genome-wide copy number profiling: precision medicine analysis of 203 pediatric brain tumors** *NEURO-ONCOLOGY*  
Ramkissoon, S. H., Bandopadhyay, P., Hwang, J., Ramkissoon, L. A., Greenwald, N. F., Schumacher, S. E., O'Rourke, R., Pinches, N., Ho, P., Malkin, H., Sinai, C., Filbin, M., Plant, et al  
2017; 19 (7): 986–96
- **Genomic profile of human meningioma cell lines** *PLOS ONE*  
Mei, Y., Bi, W., Greenwald, N. F., Agar, N. Y., Beroukhi, R., Dunn, G. P., Dunn, I. F.  
2017; 12 (5): e0178322
- **Genomic landscape of high-grade meningiomas** *NPJ GENOMIC MEDICINE*  
Bi, W., Greenwald, N. F., Abedalthagafi, M., Wala, J., Gibson, W. J., Agarwalla, P. K., Horowitz, P., Schumacher, S. E., Esaulova, E., Mei, Y., Chevalier, A., Ducar, M. A., Thorner, et al  
2017; 2
- **Landscape of Genomic Alterations in Pituitary Adenomas** *CLINICAL CANCER RESEARCH*  
Bi, W., Horowitz, P., Greenwald, N. F., Abedalthagafi, M., Agarwalla, P. K., Gibson, W. J., Mei, Y., Schumacher, S. E., Ben-David, U., Chevalier, A., Carter, S., Tiao, G., Brastianos, et al  
2017; 23 (7): 1841–51
- **Increased expression of programmed death ligand 1 (PD-L1) in human pituitary tumors** *ONCOTARGET*  
Mei, Y., Bi, W., Greenwald, N. F., Du, Z., Agar, N. R., Kaiser, U. B., Woodmansee, W. W., Reardon, D. A., Freeman, G. J., Fecci, P. E., Laws, E. R., Santagata, S., Dunn, et al  
2016; 7 (47): 76565–76