



## Graduate students' interest in immunology as a discipline

Alexander Kwarteng, Michael Frimpong, Augustina Angelina Sylverken, Yarhands D. Arthur, Samuel T. Ahuno & Ellis Owusu-Dabo |

To cite this article: Alexander Kwarteng, Michael Frimpong, Augustina Angelina Sylverken, Yarhands D. Arthur, Samuel T. Ahuno & Ellis Owusu-Dabo | (2017) Graduate students' interest in immunology as a discipline, Cogent Education, 4:1, 1398705, DOI: [10.1080/2331186X.2017.1398705](https://doi.org/10.1080/2331186X.2017.1398705)

To link to this article: <https://doi.org/10.1080/2331186X.2017.1398705>



© 2017 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license



Published online: 10 Nov 2017.



Submit your article to this journal [↗](#)



Article views: 2471



View related articles [↗](#)



View Crossmark data [↗](#)



Received: 18 July 2017  
Accepted: 26 October 2017  
First Published: 01 November 2017

\*Corresponding author: Alexander Kwarteng, Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana; Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR), Kumasi, Ghana  
E-mail: [akwarteng@knust.edu.gh](mailto:akwarteng@knust.edu.gh)

Reviewing editor:  
John Lee, Hong Kong Institute of Education, Hong Kong

Additional information is available at the end of the article

## EDUCATION POLICY | RESEARCH ARTICLE

# Graduate students' interest in immunology as a discipline

Alexander Kwarteng<sup>1,2\*</sup>, Michael Frimpong<sup>2</sup>, Augustina Angelina Sylverken<sup>2,3</sup>, Yarhands D. Arthur<sup>4</sup>, Samuel T. Ahuno<sup>1</sup> and Ellis Owusu-Dabo<sup>2,5</sup>

**Abstract:** Interest and motivation significantly influence achievement; however, interest in immunology remains to be determined. Using a structured questionnaire, the current study assessed for the first time interest in immunology among biomedical graduate students in Ghana after a one-week introduction to immunology course. Our results revealed that approximately 80% of study participants expressed an interest in immunology. In addition, we showed that interest in immunology was independent of age and gender of the study participants. More interestingly, we observed that interest in immunology was primarily influenced by career choice. The findings from the present study have implications on immunology education and calls for investment in building capacity in immunology especially in developing countries.

**Subjects:** Medicine; Infectious Diseases; Allied Health

**Keywords:** immunology; interest; students; graduates; Ghana

### 1. Introduction

The face of health care is changing by the day in developing countries with the introduction of new biomedical based-programs. Immunology is currently taking centre stage in the field of life sciences (Horton, Smith, Gershon, & O'Brien, 1997). The subject practically affects several aspects of medicine;

### ABOUT THE AUTHOR

Alexander Kwarteng, PhD, in Molecular Biomedicine is a faculty at the Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana. Kwarteng is passionate about immunology education and training in developing countries and has in the past been involved in the development of courses and instructional materials centred on this theme. He posits that effective training of immunologists will demand huge capital and resource investment given the high cost of establishing and maintaining immunology core facilities, to run experiments, demonstrations and practical sessions. He believes that developing countries have other urgent sectors to support with limited resources; however, given the benefits of immunology education and research, these nations should reconsider dedicating adequate financial support and national commitment to the area of immunology education and research to quickly bridge the huge deficit of immunologists in developing countries.

### PUBLIC INTEREST STATEMENT

Immunology, a biomedical discipline, is the study of how the body responds to infectious/foreign agents. The discipline is increasingly gaining prominence in biomedical sciences and practice. Students' interest in any discipline/subject affects students' level of learning, academic performance, competence and quality of their learning experience. Given the significant health benefits of immunology education and research, particularly in developing countries with massive health needs, we determined for the first time Ghanaian students' interest in immunology. Despite the complexity of the subject, students in this study reported high levels of interest in immunology and interest correlated with career choices. This study has huge implications in medical research and could be extended to other biomedical disciplines to support biomedical education in the twenty-first century. Further studies to investigate what are the underlying factors of students' interest in immunology are recommended.

however, it is often considered as complex, with huge unawareness in the biomedical science community, especially in the areas of tropical diseases despite its valuable contributions (Wilson & Dunne, 2014). Immunology has grown exponentially in the past years and continues to break grounds with seminal findings in areas such as cytokine biology, vaccine development and transplantation. The rapid growth of both basic and applied immunology requires specialised training (Bishop, 2015; Wilson & Dunne, 2014) to cope with the growing demand to resolving key public health challenges, particularly in developing countries.

Immunology plays a central role in the diagnosis and management of a variety of immune-mediated conditions. It is known that diagnostic evaluation of immune function is critical to the manipulation of the immune system through the use of biological and other drug-induced immune responses in various clinical contexts. Furthermore, it has been established that understanding of the regulation of host immune response is key to formulating new methods to diagnosis and treatment of immune-based diseases (Tebo et al., 2014). Given that the developing world is often hit by epidemics, there is the need for well-trained individuals alongside appropriate intervention measures. In fact, the recent epidemic of Ebola virus disease (EVD) in West Africa claimed many lives (Hageman et al., 2016), because of the ill-prepared healthcare workers coupled with poor research facilities and/or health centres in the most hit communities (Annan et al., 2017).

While basic and applied immunology continues to grow at a fast pace with new findings, training individuals who can translate these immunological findings into useful applications in order to rapidly respond to future outbreaks is non-negotiable. In other jurisdictions, however, there has been calls to train young immunologists to contribute to multidisciplinary research on all NTDs (Wilson & Dunne, 2014), and to handle huge data resources because of the increasing trends to omics-based approaches, which has the potential to identify relevant regulators of immune-related mechanisms (Schultze, 2015; Spreafico, Mitchell, & Hoffmann, 2015).

It has been suggested that interest, goals and motivation are key for learning and academic achievement, and thus students pay particular attention to a certain field once they are interested, making them able to observe carefully, memorise well and think actively. Immunology now remains a centre of life sciences, with a complex and expansive subject curriculum. In order to train the right calibre of students with in-depth insight and skills to address the emerging and re-emerging infections in endemic areas, it is imperative to stimulate students' interest in immunology, thereby enhancing their enthusiasm while helping them to better appreciate the concepts and techniques. Toward this goal, the current study investigated, for the first time, the level of motivation and interest for immunology among Ghanaian biomedical science graduate students.

## 2. Methods

The participants were Biomedical Science Graduate students drawn from the Department of Theoretical and Applied Biology, Department of Biochemistry and Biotechnology, School of Medical Sciences all from the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. These were participants of a one-week workshop in "Introduction to Immunology" organised at Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR) as part of a bigger study, which sought to assess the immune profile of children with *Mycobacterium tuberculosis* infection in Ghana. Questionnaires for this study were self-constructed based on students' areas of difficulty over several years of teaching immunology course. Similarly, participants were asked to provide basic information such as gender, age, course of study, graduating class among others. Graduate students' preference for mode of delivery by lecturers in immunology was investigated using a five point Likert-scale. Reliability of the mode of delivery by lecturers in immunology was calculated using Cronbach's  $\alpha$  coefficient (0.867). The high values of reliability coefficient in this study suggest that the instruments used to investigate graduate students' preferred mode of delivery by lecturers are reliable and thus are appropriate for further studies. A structured questionnaire was administered to all participants at the end of the workshop.

### 2.1. Ethical approval

The study was part of an immune profile study in individuals with *M. tuberculosis* infection in Ghana approved by the Committee on Human Research, Publication and Ethics (CHRPE) of the School of Medical Sciences of the Kwame Nkrumah University of Science and Technology, Ghana (Approval Number: CHRPE/AP/179/16). Study procedures were in accordance with the Helsinki Declaration of 2000.

### 2.2. Statistical analysis

Data were analysed with SPSS version 19.0. Descriptive statistical analyses as well as non-parametric  $\chi^2$  test of independence and Fisher Exact test were performed.

## 3. Results

### 3.1. Descriptive statistics of the study participants

A total of thirty-two ( $N = 32$ ) participants were recruited for the study. Of these, there were more males (61.3%, 19) than females (38.7%, 12) (Table 1). The majority of the students were within the 23–25 (31.2%) and 28–35 age groups (31.2%). In addition, 46.9% of the participants were Biological Science graduates while 21.9% were Biochemistry graduates. However, 31.2% were graduates from other Biomedical science programs. Of the graduating classes, 17.2, 65.6, 17.2% had first class, second class upper, and second class lower divisions, respectively.

### 3.2. Students' interest and motivation

To determine the level of students' interest in immunology, we used structured questionnaire. Here, 78.1% stated that they were interested in immunology while 21.9% had no interest in immunology (Table 2). More than three quarters (84.4%) of the participants enjoyed studying the course while less than a quarter (15.6%) did not enjoy immunology. After the short-course, 84.4% reported that they gained extra knowledge in immunology while 15.6% did not. Moreover, almost all the participants (93.3%) responded that they had gained interest in immunology after the course, however, 6.7% indicated otherwise. Surprisingly, more than half (54.8%) of the study participants were of the view that they did not have the needed materials to study immunology whereas 45.2% felt they had access to the necessary materials. In addition, our results showed that students' interest was dependent on availability of study materials ( $p = 0.037$ ). On the other hand, 87.5% of the participants

**Table 1. Demographics of the participants**

Variable	Frequency
<i>Gender</i>	
Male	19 (61.3%)
Female	12 (38.7%)
<i>Age group</i>	
20–22	4 (12.5%)
23–25	10 (31.2%)
26–28	8 (25%)
28–35	10 (31.2%)
<i>Undergraduate education programs</i>	
Biological Sciences	15 (46.9%)
Biochemistry	7 (21.9%)
Others	10 (31.2%)
<i>Graduating class</i>	
First class	5 (17.2%)
Second class Upper	19 (65.6%)
Second class lower	5 (17.2%)

**Table 2. Distribution of students' interest in immunology and motivation**

Variable	Frequency
Students' positive Interest in immunology	25 (78.1%)
No Interest in immunology	7 (21.9%)
Enjoy studying immunology	27 (84.4%)
Fraction that do not enjoy studying immunology	5 (15.6%)
Knowledge gained after short course	27 (84.4%)
No knowledge gained after short course	5 (15.6%)
Interest gained after short course	30 (93.7%)
No interest gained after short course	2 (6.3%)
Positive motivation towards immunology	28 (87.5%)
No motivation towards immunology	4 (12.5%)

**Table 3. Significance of interest in immunology with age, gender and eagerness to study immunology**

Variable	p-value
Graduating class and students' interest	0.29
Interest in immunology and study of immunology	0.45
Interest in immunology and age	0.24
Interest in immunology and gender	0.06

were motivated to study immunology while 12.5% had no motivation whatsoever in immunology. Of the motivated students, 21.4% were extremely interested, 53.6% were highly interested and 25% were just interested. The intensity of non-motivation was apparently minimal as 18.8% of the participants who reported no motivation rated their level of non-motivation as just "not motivated". Interestingly, the majority of the participants (87.5%) were of the view that their individual carrier choices could influence their interest in immunology as shown in Table 2.

### 3.3. Interest in immunology and students performance

To determine whether interest in immunology was associated with the participants graduating class of study, we performed  $\chi^2$  analysis. The results showed that interest in immunology was independent of graduating class ( $p \geq 0.05$ ). Furthermore, we observed that interested in immunology was independent of enjoying the study of immunology ( $p \geq 0.05$ ) as shown in Table 3.

### 3.4. Students interest in immunology vs. age and gender

Having observed that interest in immunology was independent of the graduating class, we further assessed whether students interest in immunology could be influenced by age among study participants. Here, a Fisher's Exact test showed that interest in immunology was independent of age ( $p \geq 0.05$ ) (Table 3). To determine whether students' interest in immunology was influenced by gender, we performed a  $\chi^2$  analysis. The results indicate that students' interest in immunology was independent of gender ( $p \geq 0.05$ ) (Table 3).

### 3.5. Students preferred mode of delivery by lecturers

To determine students' preferred methods of the course instruction, we performed a relative importance test index analysis on the mode of delivery. The test of reliability using Cronbach's  $\alpha$  yielded 0.867. The interactive method ranked highest (0.838) followed by teaching using PowerPoint presentations (0.806). These were followed by teaching methods such as Demonstrations (0.787) and then Lectures (0.744) as shown in (Table 4).

**Table 4. Students' relative importance to teaching methods**

Teaching methods	Relative importance	Cronbach $\alpha$
Interactive	0.838	0.867
Powerpoint	0.806	
Demonstration	0.787	
Lecture	0.744	

#### 4. Discussion

Immunology as a discipline has experienced a tremendous growth over the past decades triggered by recent studies to deepen the understanding of the innate and adaptive response and how the molecular components interplay to provide immunity (Bishop, 2015). The understanding of the innate and adaptive immunity as well as orchestrated protective mechanisms of several immune components has deepened our knowledge of host-pathogen interaction and the immuno-biology of infections. However, students' interest in immunology, just like other related biological disciplines, and prior to this study remains undetermined among Ghanaian students. Prior to the current study, 50% of the interviewed graduate students in an informal survey at the Kumasi Centre for Collaborative Research (KCCR) expressed no interest in immunology.

To this end, the current study investigated the interest and motivation of Ghanaian biomedical science graduates in immunology following a week-long short course in Introduction to Immunology for biomedical science students. In this study, we observed that almost 80% of the study participants were interested in immunology while 20% were not. This finding was in line with another set of questions that sought to find out whether the participants had gained extra knowledge in immunology after the course, suggesting the need for further training in immunology. Furthermore, our findings indicate that almost 85% had gained knowledge, whereas a quarter indicated otherwise. On the level of motivation, it was interesting to reveal that 87.5% of the study participants were motivated to study immunology after the course while the remainder had no motivation to study immunology. Given that interest and motivation are driven by several factors, we assessed some of the potential factors that could influence students' interest in immunology.

Here, our results illustrate that 90% of the study participants' interest in immunology was influenced by career choice. Interestingly in a recent report by Hannum et al., it was suggested that introduction of immunology at the undergraduate level has great potentials in identifying bright and smart students in their early career choice (Hannum, Kurt, & Walser-Kuntz, 2016). Accordingly, well-trained immunologists will be key to driving life science career opportunities in academia, particularly in developing countries, where the increasing emergence of infectious diseases is coupled with many neglected tropical diseases. Training immunologists to handle some of the immunology related challenges at the clinic and research front will bring us closer to understanding diseases mechanisms (particularly NTDs) as well as identifying suitable vaccine candidates (Wilson & Dunne, 2014), especially in the era of 'omics' biology (Schultze, 2015; Whelan, Yap, Surette, Golding, & Bowdish, 2013).

Immunology is considered the field with ever-changing concepts and inherent complexity by both observers and experts alike. Despite being in its infancy, benefiting from the current creative minds driven by a sense of inquiry, its roles in both health and medicine remains indispensable. Furthermore, our results illustrate that interest in immunology is independent of graduating class. This is an interesting observation but contrasts the hypothesis of the direct proportional relationship between interest and student performance (Abrantes, Seabra, & Lages, 2007). In addition, in the current study, we showed that student interest in immunology is not influenced by gender, suggesting that both male and female students have equal opportunity to excel in immunology programs and that both sexes need to be motivated and encouraged. Assuming this sample is representative of a larger population of biomedical science graduate students, the profile of prospective immunologists will be fairly represented in both gender. This is in contrast to previous studies in Mathematics, where males

showed more interest compared to females (Frenzel, Goetz, Pekrun, & Watt, 2010). Similarly, in another study, females showed significantly greater interest in biology compared to boys (Prokop, Prokop, & Tunnicliffe, 2007). Our data is not in agreement with previous studies in New Zealand, where it was observed that medical students' speciality was significantly influenced by gender (Boyle, Shulruf, & Poole, 2014). Discrepancies in results from the above studies are not clear, but subject-specific preferences could be an important driving factor among others.

Furthermore, we showed that students' interest in immunology is independent of the age of the study participants. Such an observation has many important implications, i.e. immunology programs could be introduced even at the undergraduate level, and thus will provide a strong foundation for postgraduate studies in immunology in line with previous reports (Abrantes et al., 2007; Bishop, 2015; Hannum et al., 2016). Given that immunology is an interdisciplinary subject and has taken a centre stage in the field of biomedical science today, early introduction of the subject is therefore crucial to building the interest of students. However, we did not investigate whether interest in immunology was dependent on the level of education, an area which requires further investigation.

In addition, we showed that students preferred the interactive mode of course delivery by tutors compared to other conventional teaching methods such as PowerPoint presentations, Lecturing and Demonstrations. The Interactive mode of delivery ensured that students are able to ask questions and get inputs from peers and friends while the course is being taught. In addition, students are able to engage in peer-review activities when tutors adopt the interactive mode teaching immunology. PowerPoint presentations, perhaps the most popular form of instruction, have been flagged as not being highly preferred by students studying immunology. Students' low appreciation of the traditional lecturing methods, as indicated by our results is very striking, which therefore calls for tutors in other biology related courses to perhaps reconsider their current mode of course delivery. Elsewhere, it has been demonstrated that medical students' interest in alternative medicine is influenced by many factors, such as availability of teaching and learning materials and mode of delivery of course among others (Greiner, Murray, & Kallail, 2000). In addition to student interest (Scott, Gowans, Wright, & Brenneis, 2012), motivation has also been shown to be influenced by career choice as well (Zampieron, Buja, Dorigo, Bonso, & Corso, 2012). Compared to other disciplines in biomedical sciences, not much has been given to immunology training, particularly in developing countries.

Another interesting observation made in the study was that despite an appreciable number of students showing high levels of interest in immunology, the majority of the study participants had no access to the necessary materials for studying immunology. Nevertheless, such an observation is not uncommon, because materials in immunology are apparently expensive and not easily accessible by most students in this part of the world. This, therefore, presents a major concern which must be addressed among other things to strengthen students' interest in immunology, particularly in developing countries.

It is clear that immunology has opened up new frontiers in the development of novel treatment options such as in the treatment of cancer, allergies and autoimmune diseases as well as infectious diseases. Our study has huge implications for medical education and research given that immunology is the bedrock of medical research and of significant importance to developing countries that have huge infectious disease burden. Therefore, to effectively contribute to fighting most infectious diseases, there is no better time than now to focus on immunology education in developing countries. However, we seem to be far behind in educating immunologists to competently handle immunology related issues in our health and research fronts especially in developing countries. There is the possibility to extend this study or experimental approaches to other biomedical fields, particularly in developing countries. We suggest inferential studies to determine the underlying factors that actually predict students' interest in immunology.

## 5. Conclusion

While the present study may not have addressed every aspect of students' perception of immunology in Ghana, given the apparent limitations such as low sample size and the absence of pre-survey data, it provides some key insights which may be explored in future studies. Taken together, we showed for the first time in this study that about 80% of biomedical science graduate students in Ghana have an interest in immunology and this interest is significantly influenced by career choice. However, the majority of the students lacked the necessary materials for studying immunology, therefore initiatives in providing these materials would hugely enhance students' interest in the course. The findings in this study provide compelling evidence to encourage immunology education, particularly in developing countries, given the huge potential it has in bridging biomedical research and clinical applications.

## Acknowledgements

We thank all study participants who took part in the Introduction to the Immunology course at KCCR, Kumasi, Ghana for taking their time to go through the questionnaire.

## Funding

The authors received no direct funding for this research.

## Author details

Alexander Kwarteng<sup>1,2</sup>

E-mail: [akwarteng@knust.edu.gh](mailto:akwarteng@knust.edu.gh)

ORCID ID: <http://orcid.org/0000-0002-0893-2908>

Michael Frimpong<sup>2</sup>

E-mail: [mfrimpong28@gmail.com](mailto:mfrimpong28@gmail.com)

Augustina Angelina Sylverken<sup>2,3</sup>

E-mail: [asylverken@knust.edu.gh](mailto:asylverken@knust.edu.gh)

Yarhands D. Arthur<sup>4</sup>

E-mail: [day1981boy@yahoo.com](mailto:day1981boy@yahoo.com)

Samuel T. Ahuno<sup>1</sup>

E-mail: [ekwame001@gmail.com](mailto:ekwame001@gmail.com)

ORCID ID: <http://orcid.org/0000-0002-1327-0195>

Ellis Owusu-Dabo<sup>2,5</sup>

E-mail: [owusudabo@kccr.de](mailto:owusudabo@kccr.de)

<sup>1</sup> Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

<sup>2</sup> Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR), Kumasi, Ghana.

<sup>3</sup> Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

<sup>4</sup> Department of Interdisciplinary Studies, University of Education, Winneba, Kumasi-Campus, Ghana.

<sup>5</sup> School of Public Health, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

## Citation information

Cite this article as: Graduate students' interest in immunology as a discipline, Alexander Kwarteng, Michael Frimpong, Augustina Angelina Sylverken, Yarhands D. Arthur, Samuel T. Ahuno & Ellis Owusu-Dabo, *Cogent Education* (2017), 4: 1398705.

## References

- Abrantes, J. L., Seabra, C., & Lages, L. F. (2007). Pedagogical affect, student interest, and learning performance. *Journal of Business Research*, 60(9), 960–964. <https://doi.org/10.1016/j.jbusres.2006.10.026>
- Annan, A. A., Yar, D. D., Owusu, M., Biney, E. A., Forson, P. K., Okyere, P. B., ... Owusu-Dabo, E. (2017). Health care workers indicate ill preparedness for Ebola virus disease outbreak in Ashanti Region of Ghana. *BMC Public Health*, 17(1), 546. <https://doi.org/10.1186/s12889-017-4474-6>
- Bishop, G. A. (2015). Yes, we need PhD immunologists!. *Trends in Immunology*, 36(5), 280–282. <https://doi.org/10.1016/j.it.2015.03.003>
- Boyle, V., Shulruf, B., & Poole, P. (2014). Influence of gender and other factors on medical student specialty interest. *The New Zealand Medical Journal*, 127(1402), 78–87.
- Frenzel, A. C., Goetz, T., Pekrun, R., & Watt, H. M. G. (2010). Development of Mathematics Interest in Adolescence: Influences of Gender, Family, and School Context. *Journal of Research on Adolescence*, 20(2), 507–537. <https://doi.org/10.1111/jora.2010.20.issue-2>
- Greiner, K. A., Murray, J. L., & Kallail, K. J. (2000). Medical student interest in alternative medicine. *The Journal of Alternative and Complementary Medicine*, 6(3), 231–234. <https://doi.org/10.1089/acm.2000.6.231>
- Hageman, J. C., Hazim, C., Wilson, K., Malpiedi, P., Gupta, N., Bennett, S., ... Park, B. J. (2016). Infection prevention and control for Ebola in health care settings - West Africa and United States. *MMWR Supplements*, 65(3), 50–56. <https://doi.org/10.15585/mmwr.su6503a8>
- Hannum, L., Kurt, R. A., & Walsler-Kuntz, D. R. (2016). Developing Immunologists: A role for undergraduate education. *Trends in Immunology*, 37(7), 425–426. <https://doi.org/10.1016/j.it.2016.03.008>
- Horton, B., Smith, O., Gershon, D., & O'Brien, C. (1997). Diverse opportunities for immunologists. *Nature*, 385(6617), 657–658. <https://doi.org/10.1038/385657a0>
- Prokop, P., Prokop, M., & Tunncliffe, S. D. (2007). Is biology boring? Student attitudes toward biology. *Journal of Biological Education*, 42(1), 36–39. <https://doi.org/10.1080/00219266.2007.9656105>
- Schultze, J. L. (2015). Teaching 'big data' analysis to young immunologists. *Nature Immunology*, 16(9), 902–905. <https://doi.org/10.1038/ni.3250>
- Scott, I., Gowans, M., Wright, B., & Brenneis, F. (2012). Stability of medical student career interest: A prospective study. *Academic Medicine: Journal of the Association of American Medical Colleges*, 87(9), 1260–1267. <https://doi.org/10.1097/ACM.0b013e31826291fa>
- Spreafico, R., Mitchell, S., & Hoffmann, A. (2015). Training the 21st century immunologist. *Trends in Immunology*, 36(5), 283–285. <https://doi.org/10.1016/j.it.2015.04.001>
- Tebo, A. E., Detrick, B., Hamilton, R. G., Khanolkar, A., O'Gorman, M. R., Schmitz, J. L., & Abraham, R. S. (2014). Clinical laboratory immunology: An indispensable player in laboratory medicine. *American Journal of Clinical Pathology*, 142(4), 437–444. <https://doi.org/10.1309/AJCPX25MFWNEYRIG>
- Whelan, F. J., Yap, N. V., Surette, M. G., Golding, G. B., & Bowdish, D. M. (2013). A guide to bioinformatics for immunologists. *Frontiers in Immunology*, 4, 416.

Wilson, S., & Dunne, D. W. (2014). A pressing need for parasite immunologists to contribute to our understanding of human-neglected tropical diseases. *Parasite Immunology*, 36(8), 325–327. <https://doi.org/10.1111/pim.2014.36.issue-8>

Zampieron, A., Buja, A., Dorigo, M., Bonso, O., & Corso, M. (2012). A comparison of student motivation in selecting bachelors of nursing or paediatric nursing at an Italian university. *International Nursing Review*, 59(4), 525–531. <https://doi.org/10.1111/inr.2012.59.issue-4>



© 2017 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.

You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.



**Cogent Education (ISSN: 2331-186X) is published by Cogent OA, part of Taylor & Francis Group.**

**Publishing with Cogent OA ensures:**

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

**Submit your manuscript to a Cogent OA journal at [www.CogentOA.com](http://www.CogentOA.com)**

