

## Misconceptions About Immunological Concepts in Current Tunisian Biology Textbooks

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### ABSTRACT

Textbook remains a compulsory reference document especially for students and teachers. Although, it may be a source of misconceptions. The goal of this paper is to determine misconceptions about immunological concepts in current tunisian biology textbooks based on Hershey method. Textbooks content is compared to books and papers reference contents. Misconceptions obtained are categorized in five categories : over-generalization, under-generalization, over-simplification, mis-identification and obsolete concepts and terms. Results show that all textbooks analyzed contain mistakes, textbooks that contain the highest number of misconceptions are the 4th SSTLESESS and 1st SSTLES because they are the oldest, whereas the lowest one is the 3ed SSBSSS because its the newest. The highest categories are over-generalization and under-generalization while the lowst one is over-simplification. The highest sub-concept that is mistakenly conceived is pathogens and diseases while the lowest one is immune barriers. Furthermore, same misconceptions are found in different textbooks. Furethemore, their content must be updated according to recent scientific progress.

**Key Words:** Misconceptions, biology textbooks, immunological concepts.

## Güncel Tunus Biyoloji Ders Kitaplarında İmmünolojik Kavramlara İlişkin Kavram Yanılgıları

### ÖZ

Ders kitabı özellikle öğrenciler ve öğretmenler için zorunlu bir başvuru belgesi olmaya devam etmektedir. Bununla birlikte, yanlış anlamaların bir kaynağı olabilir. Bu makalenin amacı, Hershey yöntemine dayalı olarak mevcut Tunus biyoloji ders kitaplarındaki immünolojik kavramlar hakkındaki yanlış anlamaları belirlemektir. Ders kitaplarının içeriği, kitap ve makale referans içerikleriyle karşılaştırılır. Elde edilen kavram yanılgıları, aşırı genelleme, eksik genelleme, aşırı basitleştirme, yanlış tanımlama ve eskimiş kavram ve terimler olmak üzere beş kategoride sınıflandırılmıştır. Sonuçlar, incelenen tüm ders kitaplarının hata içerdiğini, en fazla kavram yanılgısını içeren ders kitaplarının 4. SSTLESESS ve 1. SSTLES olduğunu, en düşük olanın ise en yeni olduğu için 3d SSBSSS olduğunu göstermektedir. En yüksek kategoriler aşırı genelleme ve yetersiz genelleme, en düşük kategori ise aşırı basitleştirmedir. Yanlış düşünülen en büyük alt kavram mikroplar ve hastalıklar iken en alt kavram ise bağışıklık engelleridir. Ayrıca farklı ders kitaplarında da aynı kavram yanılgılarına rastlanmaktadır. Dahası, içerikleri son bilimsel gelişmelere göre güncellenmelidir.

**Anahtar Kelimeler:** Kavram yanılgıları, biyoloji ders kitapları, immünolojik kavramlar

# 1. Introduction

Since the medieval time, there were many difficulties in biology conceptualization. In particular, within the evolution theory postulation during the eighteenth century, misconceptions instigate from religion and socioculture of populations (Silva et al, 2021). These erroneous representations concern all students and learners at any scholar level and remain a harsh problem matter for understanding biology.

Pragmatically, misconception designates conception that contradict the scientifically accepted thesis (Curel et al, 2015). In other words, it means the interpretation of concepts in an erroneous way (Raharjo et al, 2018). It forms strong and firm barrier for students to understand biological concepts (Tekkaya, 2002). The origins of misconception are diverse and can emanate from student pre-conceptions, teachers' knowledge and methods, biological matters and textbooks (Suparno, 2013).

Textbook is viewed as reliable material which provide creditable information that helps and improves students' understanding (Knight, 2015). However, it can contain some mistakes in explanations or descriptions leading to further students' misconceptions (Galvin et al, 2015).

According to Hershey (2005), misconceptions are subdivided into five categories : Under-generalizations (very narrow applications of concepts), obsolete concepts and terms (concepts and terms that are no longer used), over-simplifications (concepts explained in such simple way to the extent that many parts of the concept are missing), over-generalizations (information is rendered too broader that students are unable to understand the real concept), and misidentifications (incorrect identification of concepts). Within the continuously introduced new knowledge in biology, textbooks might contain more and more misconceptions because of default of updating. Manuscripts are profoundly influenced by cultural, religious, political and socioeconomic factors (Silva et al, 2021) Several papers studied misconceptions present in biology textbooks, such as plants (Hershey 2004, 2005), bacteria (Novitasari et al, 2019), protist (Raharjo et al, 2018), virus (Saputri & Widyaningrum, 2016), and many other subjects. Immunology is a very complexified part of biology and remains vulnerable to misconceptions. Actually, Dowdy and D'Souze suggested that misconceptions about the importance of immunity in Covid 19 dissimulation might drive a catastrophic event. It was though that herd immunity within a specific period might slow down the infection's spread, but it is not the real case (Dowdy and D'Souze, 2020). Such

misconceptions in immunology is thought to originate from complexity of its concepts, media and textbooks (Saputri & Widyaningrum, 2016).

In such point of view, this paper is intended to identify and discuss misconceptions concerning immunological concepts in current Tunisian biology textbooks

## 2. Method

The present study is a descriptive research based document content analysis method, in order to detect and discuss misconceptions in immunity. Secondary schoolar Tunisian textbooks were analyzed and compared to references books (Gros et al, 2018 ; Raven et al, 2020). Recent scientific reports were also used to entale the different categories of misconceptions. The biology textbooks used were four books (Table 1) :

- First year secondary school textbook of life and earth sciences
- First year secondary school textbook of biological sciences ; sport section
- Third year secondary school textbook of biological sciences ; sport section
- And fourth year secondary school textbook of life and earth sciences ; experimental sciences section.

## 3. FINDINGS

The approach of research involved :1) conducting a survey to current tunisian textbooks of biology used in secondary schools, 2) selecting textbooks that study immunology, 3) concieving instrument tables of textbooks analysis, 4) collecting misconceptions in comparing textbooks contents to book and papers reference contents, 5) categorizing misconceptions on four categories based on immunological sub concepts (pathogens and diseases, immune cells, immune molecules and natural barrieres), 5) categorizing misconceptions using Hershey method (2005) including five categories : under-generalizations, obsolete concepts and terms, over-simplifications, over-generalizations, and mis-identifications.

**Table 1.**

Characteristics of the textbooks under examination

<b>Characteristics</b>	<b>First year secondary school textbook of life and earth sciences (1<sup>st</sup> SSTLES)</b>	<b>First year secondary school textbook of biological sciences ; sport section (1<sup>st</sup> SSBSSS)</b>	<b>Third year secondary school textbook of biological sciences ; sport section (3<sup>rd</sup> SSBSSS)</b>	<b>Fourth year secondary school textbook of life and earth sciences ; experimental sciences section (4<sup>ed</sup> SSTLESESS)</b>
<b>Curriculum Reference</b>	2003	2012	2012	2003
<b>Year of publication</b>	2004	2012	2014	2004
<b>Number of pages</b>	199	157	271	344
<b>Title of theme analyzed</b>	Microbes and health	Microbes and health	Immunity and the integrity of the organism	Immunity
<b>Number of pages reserved to the theme analyzed</b>	45 (pp 89-134)	55 (pp95-150)	80 (pp 96-176)	74 (pp264-338)

**Table 2.**

Misconceptions contained in tunisian biology textbooks

Textbook	Misconception	Category	Scientific accepted theory	Ref.	Predicted misconception impact
1 <sup>st</sup> SSTLES	1. Trichophyton is a filamentous fungus that infects the skin and hair	OG	<i>Trichophyton rubrum</i> is responsible for ringworm. There are non-pathogenic trichophytions	Nenoff et al (2014)	Generalization of the pathogenic aspect to all species belonging to the genus Trichophyton
	2. Phagocyte is a polynuclear capable of ingesting a foreign element in order to eliminate it	UG	Phagocyte can be mononuclear (macrophage or dendritic cell)..	van Furth et al (1972)	Limiting the phagocytic characteristic to polynuclear cells alone
	4. Lacrimal gland secretions are acidic	MI	Tears pH is neutral or slightly basic	Yamada et al (1997)	Conception of tears as acidic solution
	1. Gut flora	OCT	Gut microbiome is made of microorganism including Archaea, Bacteria and Fungi	Hoffman et al (2013)	Conception of gut microbiome as being made of plants
	1. Microscopic fungi are microscopic, non-chlorophyllic plants	MI	Fungi and plants are two separate kingdoms	Simpson & Roger (2004)	Fungi and plants belong to the same kingdom
	1. Trypanosoma is the microbe that causes sleeping sickness	OG	Only Trypanosoma brucei causes sleeping sickness	Malvy & Chappuis (2011)	Conception that all species belonging to the genus Trypanosoma cause sleeping sickness
1 <sup>st</sup> SSBSSS	1. Fungi and bacteria are saprophytes	OCT	Saprophyte is a misleading and obsolete term	Hershey (1999)	Conception of fungi as organisms that obtain its energy directly from dead organic matter
	2. Lymphocytes are a variety of white blood cells involved in adaptative immunity	UG	Natural killer (NK) cells are lymphocytes of the innate immune system	Grégoire et al (2007)	Limiting of lymphocytes cells to the adaptative immune response
	1. Amoeba is a pathogenic microbe	OG	Some amoeba are not pathogenic Entamoeba coli and E. dispar are harmless	Issa (2014)	Generalization of the pathogenic aspect to all amoeba
	1. Tetanus is caused by Clostridium botulinum	MI	Tetanus is caused by <i>Clostridium tetani</i>	Brüggemann et al (2003)	Conception of <i>Clostridium botulinum</i> as being the cause of tetanus
	1. Fungi are parasites	OG	There are fungi that are non-parasitic	Smith et al (2015)	Generalization of the parasitic aspect to all fungi
3 <sup>rd</sup> SSBSSS	3. For ABO system, an agglutinin is a membrane glycoprotein	UG	Blood group antigens are observed on O-glycoproteins, N-glycoproteins,	Kudelka et al (2015)	Limiting of blood group antigens to membrane glycoproteins alone

and glycolipids					
<b>4<sup>th</sup> SSTLES</b>	1. Eczema is an allergy	OG	There is a non allergic form of eczema	Holgate & Lack (2005)	Generalization of allergic aspect to all types of eczema
	2. Memory B cells are the result of a proliferation phenomenon	MI	Memory B cells are the result of a differentiation phenomenon by the expression of CD27	Tangye & Good (2007)	Conception of memory B cells generation as result of proliferation phenomenon
	2. Lymphocytes are a variety of white blood cells involved in adaptative immunity	UG	Natural killer (NK) cells are lymphocytes of the innate immune system	Grégoire et al (2007)	Limiting of lymphocytes cells to the adaptative immune response
	2. LT suppressors or LTs secrete immunosuppressive factors, ensuring that the response stops when the antigen is cleared	OCT	The concept of LT suppressor is obsolete. It is modified by LT regulators	Amsallag (2019)	Limiting of the role of LT regulators to the supression of immune response
	2. Blood is made of plasma, red blood cells and white blood cells	OS	Blood is made of plasma, red blood cells, white blood cells and platelets	Smith (2006)	Neglect of the role of platelets in the immune response
	3. For ABO system, an agglutinin is a membrane glycoprotein	UG	Blood group antigens are observed on O-glycoproteins, N-glycoproteins, and glycolipids	van Furth et al (1972)	Limiting of blood group antigens to membrane glycoproteins alone

1. Pathogens and diseases, 2. Immune cells, 3. Immune molecules and 4. Immune barriers.

MI: mis-identification, OCT: obsolete concepts and terms, OG: overgeneralization, OS: over-simplification, and UG: under-generalization.

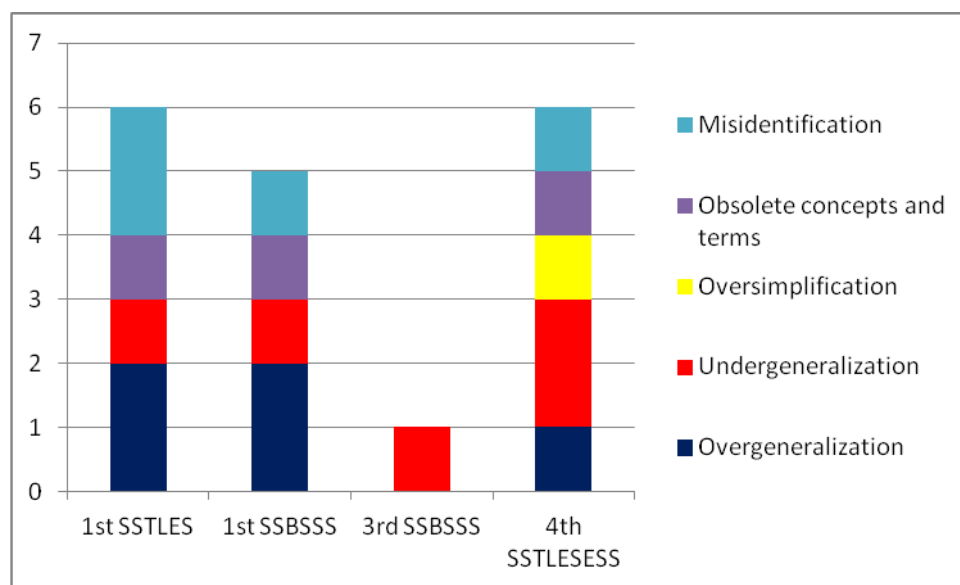
#### 4. RESULTS AND DISCUSSION

According to Yigman and Fidan (2021), the rapid world changing and the impact of life conditions brought disruption of human emotional, behavioral and cognitive responses. Specifically, textbooks considered as a prominent source of information and knowledge for students and learners, might present misconceptualizations as consequence of the rapid spreading networks data. In such context, we carried out a survey to check mistakes in immunology concepts, and found a total of 18 misconceptions in 4 Tunisian textbooks. The lowest level of these erroneous representations was observed in the 3<sup>rd</sup> SSBSSS with only one mistake of under-generalization type. The other three educational books present similar numbers (5 to 6) of misconceptions. In effect, the 3<sup>rd</sup> SSBSSS is the newest introduced textbook, hence it might have updated scientific content, fact that explains the less recorded conceptual mis-representations. The 4<sup>th</sup> SSTLES textbook -which is the oldest- contained all kinds of misconceptions including over-simplification that is missing from all other textbooks (Figure 1). Misconceptualizations fall within 5 categories (over-generalization, under-generalization, over-simplification, mis-identification and obsolete concepts and terms). Under-generalization (28%), over-generalization (28%) and mis-identification (22%) were the most encountered erroneous representations in the studied textbooks. Obsolete concepts and terms represent 17% of cases ; that particularly concern the oldest edited textbooks. The oversimplification category is represented in only one by eighteen cases (5%) (Figure 2). Similar results have been reported in recent studies (Pangestika & Widyaningrum, 2018 ; Milia and Zulyusri, 2021).

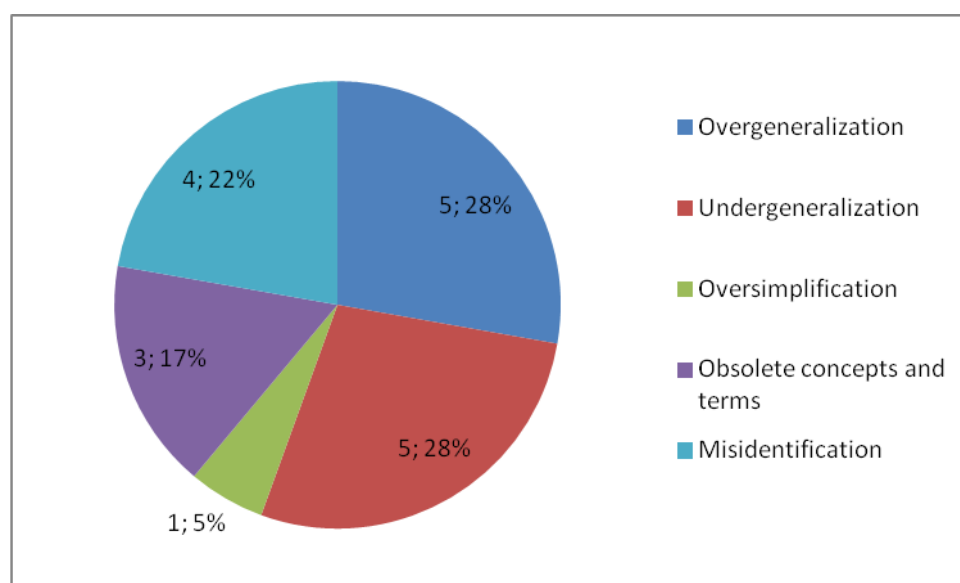
Misconceptions in immunology are subdivided into sub-categories in relationship to the studied matters (i) pathogens and diseases, (ii) immune cells, (iii) molecules and (iv) barriers. As shown in figure 3, the checked misconceptions mostly concern pathogens and diseases and immune cells (rate of 50 % and 33 %, respectively) sub-concepts (Figure 3). In agreement to our results, huge plethora of studies reported a variability of misconceptions rate in microscopic organisms with pathogenic features (Bulunuz et al, 2008 ; Rahrajo et al, 2018 ; Novitasari et al, 2019). It was also observed that some mistakes are reapprised in two textbooks, like the statement that « Lymphocytes are a variety of white blood cells involved in adaptative immunity ». This can be attributed to the same referred literature, or authors of the textbooks.

Eventually, any error in referenced textbooks lead to aggravating the misconceptions of scientific material. In our study, its expected that the checked misconceptions will impact some subsets of immune conceptualization. Generalization might induce confusion between pathogenic and non pathogenic agents ; and the adequacy/inadequacy of the respective defense responses. The blood ABO system is known by its cross reactive antigenicity that results in severe homeostatic misbalance. Considering that antigenic receptors are constituted by only glycoproteins excludes other membrane receptor compenent like glycolipids. In a such way, there will be confusion in recognizing blood donors/receptors, for example.

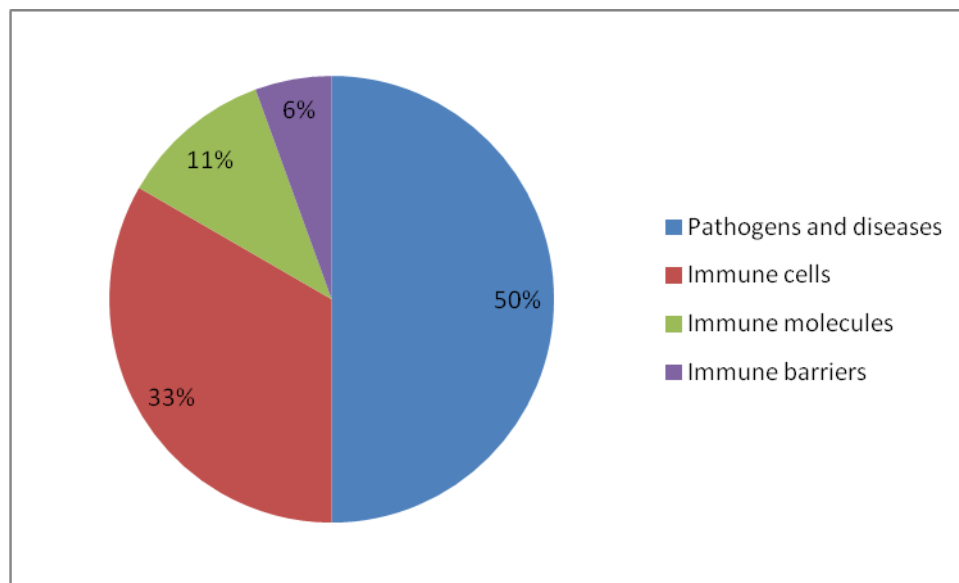
In general, misconceptualization at any level may be of intolerable dangerous consequences in cognitive, behavioral and life styles of humanity (Carlson et al, 2020 ; Schmidt et al, 2020).



**Figure 1. Diagram number of misconceptions each category in Tunisian biology textbooks**



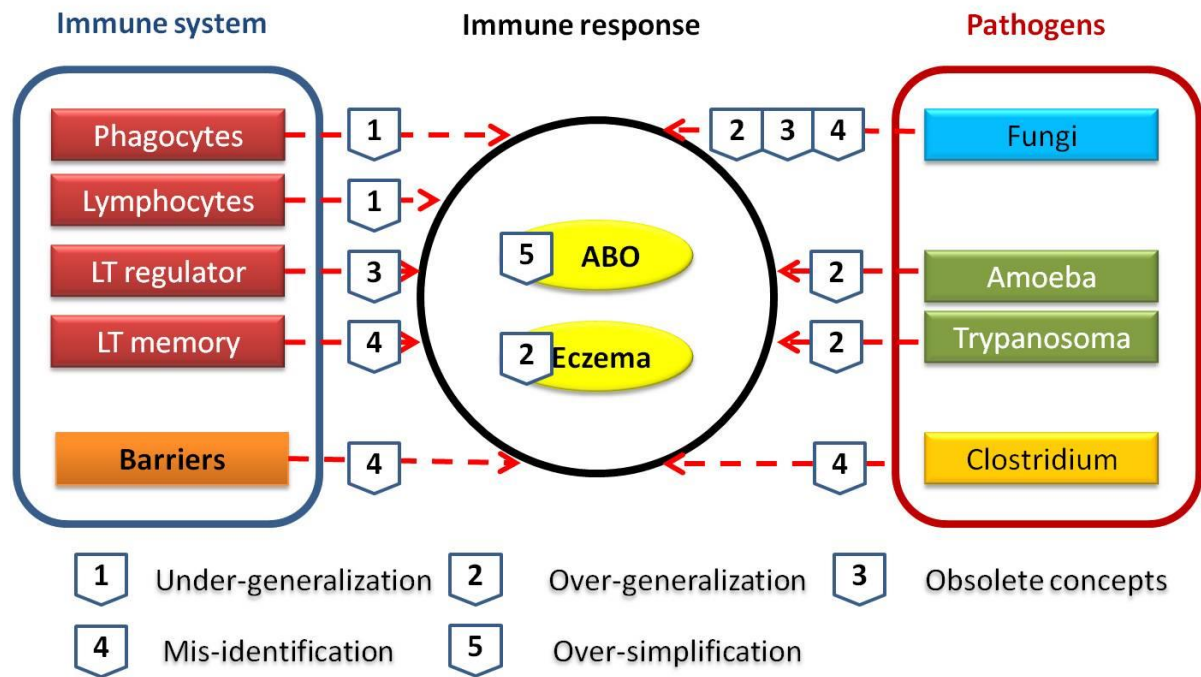


**Figure 2. Diagramm percentage of misconceptions in Tunisian biology textbooks****Figure 3. Diagram percentage of sub-concepts misconceptions in Tunisian biology textbooks**

The main reason for the happening mistakes is the intend to simplify and clarify these concepts through different didactical methods (Chevallard & Johsua, 1985 ; Paun, 2006 ; de Mello, 2017).

### Conclusion

Misconceptions represent limiting factor in front of understanding real mechanisms of biology in particular the immunological concepts. They have multiple origins including textbooks. Detection of mistakes is the first unevitable step to surpass the matter. In this work, we checked out five different kinds of misconceptions in immunology from current Tunisian textbooks. These erreneous representations did concern both the immune system components, pathogens and the defensive reaction. They fall within 5 different categories. Imperatively, the sought recognition of mechanisms of the immune response will be deeply affected, since it constitutes the talking-crossroad between pathogens and the immune system. As noticed in this survey, the mis-understanding of immune cells subsets might complicate the recognition of the immune molecular and cellular response directed against specific pathogen (Figure 4). Most of the studied Tunisian textbooks are quite old. Therefore, their content must be updated according to recent scientific progress. Large scale investigations are envisaged to better understand these conceptualizations and remediate the wounds.



**Figure 4.** Schematic representation of misconceptions in current Tunisian textbooks

## References

- Amsallag W. (2019). *Maladies autoimmunes. Un génocide immunitaire*. Varegus Publishing Nicosia Cyprus.
- Aristizábal, B., & González, Á. (2013). Innate immune system. In *Autoimmunity: From Bench to Bedside [Internet]*. El Rosario University Press.
- Birch, P. R., & Whisson, S. C. (2001). *Phytophthora infestans* enters the genomics era. *Molecular Plant Pathology*, 2(5), 257-263.
- Brüggemann, H., Bäumer, S., Fricke, W. F., Wiezer, A., Liesegang, H., Decker, I., ... & Gottschalk, G. (2003). The genome sequence of *Clostridium tetani*, the causative agent of tetanus disease. *Proceedings of the National Academy of Sciences*, 100(3), 1316-1321.
- Bulunuz, N., Jarrett, O. S., & BULUNUZ, M. (2008). Fifth-Grade Elementary School Students' Conceptions and Misconceptions about the Fungus Kingdom\*. *Journal of Turkish Science Education*, 5(3), 32-46.
- Carlson, C. J., Gomez, A. C., Bansal, S., & Ryan, S. J. (2020). Misconceptions about weather and seasonality must not misguide COVID-19 response. *Nature Communications*, 11(1), 1-4.
- Chevallard, Y., & Johsua, M. A. (1985). *La transposition didactique: du savoir savant au savoir enseigné*. La Pensée sauvage.
- De Mello, L. A. (2017). A propose of rules defining as a didactic transposition should occur or be achieved-the generalized didactic transposition theory.

- Dowdy, D., D'Souza, G. (2020). Early HErd Immunity against COVID-19: a dangerous misconception. Johns Hopkins Coronavirus Ressource Center- Johns Hopkins University.
- Galvin, E., Simmie, G. M., & O'Grady, A. (2015). Identification of misconceptions in the teaching of biology: A pedagogical cycle of recognition, reduction and removal. *Higher Education of Social Science*, 8(2), 1-8.
- Grégoire, C., Chasson, L., Luci, C., Tomasello, E., Geissmann, F., Vivier, E., & Walzer, T. (2007). The trafficking of natural killer cells. *Immunological reviews*, 220(1), 169-182.
- Gros, F., Fournel, S., Liégeois, S., Richard, D., & Soulas-Sprauel, P. (2018). *Atlas d'immunologie: De la détection du danger à l'immunothérapie*. Dunod.
- Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science.
- Hershey, D. R. (1999). Myco-heterophytes & parasitic plants in food chains. *The American Biology Teacher*, 61(8), 575-578.
- Hershey, D. R. (2004). Avoid misconceptions when teaching about plants. Available on <http://www.actionbioscience.org/education/hershey.html>, (Access on October, 31st 2016).
- Hershey, D. R. (2005). More misconceptions to avoid when teaching about plants. *American Institute of Biological Sciences*.
- Hoffmann, C., Dollive, S., Grunberg, S., Chen, J., Li, H., Wu, G. D., ... & Bushman, F. D. (2013). Archaea and fungi of the human gut microbiome: correlations with diet and bacterial residents. *PloS one*, 8(6), e66019.
- Holgate, S. T., & Lack, G. (2005). Improving the management of atopic disease. *Archives of disease in childhood*, 90(8), 826-831.
- Issa, R. A. G. A. A. (2014). Non-pathogenic protozoa. *International Journal of Pharmacy and Pharmaceutical Sciences*, 6(3), 30-40.
- Knight, B. A. (2015). Teachers' use of textbooks in the digital age. *Cogent education*, 2(1), 1015812.
- Kudelka, M. R., Ju, T., Heimbürg-Molinario, J., & Cummings, R. D. (2015). Simple sugars to complex disease—mucin-type O-glycans in cancer. In *Advances in cancer research* (Vol. 126, pp. 53-135). Academic Press.
- Malvy, D., & Chappuis, F. (2011). Sleeping sickness. *Clinical Microbiology and Infection*, 17(7), 986-995.
- Novitasari, C., Ramli, M., & Karyanto, P. (2019). Content analysis of misconceptions on bacteria in the biology textbook of high school. In *Journal of Physics: Conference Series* (Vol. 1157, No. 2, p. 022076).

- Nenoff, P., Krüger, C., Ginter-Hanselmayer, G., & Tietz, H. J. (2014). Mycology—an update. Part 1: Dermatmycoses: causative agents, epidemiology and pathogenesis. *JDDG: Journal der Deutschen Dermatologischen Gesellschaft*, 12(3), 188-210.
- Pangestika, A., & Widyaningrum, T. (2018). Identifying Conceptual Mistakes on SMA Teaching Books in Materials of Imune System for Eleventh Graders. *International Journal of Active Learning*, 3(2), 50-57.
- Paun, E. (2006). Transposition didactique: un processus de construction du savoir scolaire. *Carrefours de l'éducation*, (2), 3-13.
- Raharjo, D., Ramli, M., & Rinanto, Y. (2018, December). Misconception protist in high school biology textbooks. In *International Conference on Mathematics and Science Education of Universitas Pendidikan Indonesia*, 3, 85-90).
- Raven, P.H., Losos, J.B., Kenneth A, Mason, K.A., and Duncan, T. (2020). Biologie. De Boeck Superieur,
- Saputri, D., & Widyaningrum, T. (2016). Misconceptions analysis on The virus chapter in biology Textbooks for high school students grade X. *International Journal of Active Learning*, 1(1), 30-37.
- Schmidt, T., Cloete, A., Davids, A., Makola, L., Zondi, N., & Jantjies, M. (2020). Myths, misconceptions, othering and stigmatizing responses to Covid-19 in South Africa: A rapid qualitative assessment. *PloS one*, 15(12), e0244420.
- Silva, H. M., Oliveira, A. W., Belloso, G. V., Díaz, M. A., & Carvalho, G. S. (2021). Biology teachers' conceptions of Humankind Origin across secular and religious countries: an international comparison. *Evolution: Education and Outreach*, 14(1), 1-12.
- Simpson, A. G., & Roger, A. J. (2004). The real 'kingdoms' of eukaryotes. *Current biology*, 14(17), 693-696.
- Smith, C. P. (2006). *Essential Revision Notes for Intercollegiate MRCS: Book 2*. PasTest Ltd.
- Smith, M. E., Henkel, T. W., & Rollins, J. A. (2015). How many fungi make sclerotia?. *Fungal Ecology*, 13, 211-220.
- Suparno, P. (2013). *Misconceptions and Changes in Concepts in Physics Education*. Jakarta: PT.Grasindo.
- Tangye, S. G., & Good, K. L. (2007). Human IgM+ CD27+ B cells: memory B cells or "memory" B cells?. *The Journal of Immunology*, 179(1), 13-19.
- Tekkaya, C. (2002). Misconceptions as barrier to understanding biology. *Hacettepe Universitesi Egitim Fakultesi Dergisi-hacettepe University Journal of Education*, 23.
- van Furth, R. Z. J. J. W. H., Cohn, Z. A., Hirsch, J. G., Humphrey, J. H., Spector, W. G., & Langevoort, H. L. (1972). The mononuclear phagocyte system: a new classification of

macrophages, monocytes, and their precursor cells. *Bulletin of the World Health Organization*, 46(6), 845.

Yamada, M., Mochizuki, H., Kawai, M., Yoshino, M., & Mashima, Y. (1997). Fluorophotometric measurement of pH of human tears in vivo. *Current eye research*, 16(5), 482-486.

Yığman, F., & Fidan, S. Transdiagnostik Faktör Olarak Belirsizliğe Tahammülsüzlük. *Psikiyatride Güncel Yaklaşımlar*, 13(3), 573-587.