

© International Baccalaureate Organization 2023

All rights reserved. No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without the prior written permission from the IB. Additionally, the license tied with this product prohibits use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, whether fee-covered or not, is prohibited and is a criminal offense.

More information on how to request written permission in the form of a license can be obtained from <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organisation du Baccalauréat International 2023

Tous droits réservés. Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite préalable de l'IB. De plus, la licence associée à ce produit interdit toute utilisation de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, moyennant paiement ou non, est interdite et constitue une infraction pénale.

Pour plus d'informations sur la procédure à suivre pour obtenir une autorisation écrite sous la forme d'une licence, rendez-vous à l'adresse <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organización del Bachillerato Internacional, 2023

Todos los derechos reservados. No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin la previa autorización por escrito del IB. Además, la licencia vinculada a este producto prohíbe el uso de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales—, ya sea incluido en tasas o no, está prohibido y constituye un delito.

En este enlace encontrará más información sobre cómo solicitar una autorización por escrito en forma de licencia: <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

Biology
Standard level
Paper 2

18 May 2023

Zone A morning | **Zone B** morning | **Zone C** morning

Candidate session number

1 hour 15 minutes

--	--	--	--	--	--	--	--	--	--

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



Please **do not** write on this page.

Answers written on this page
will not be marked.

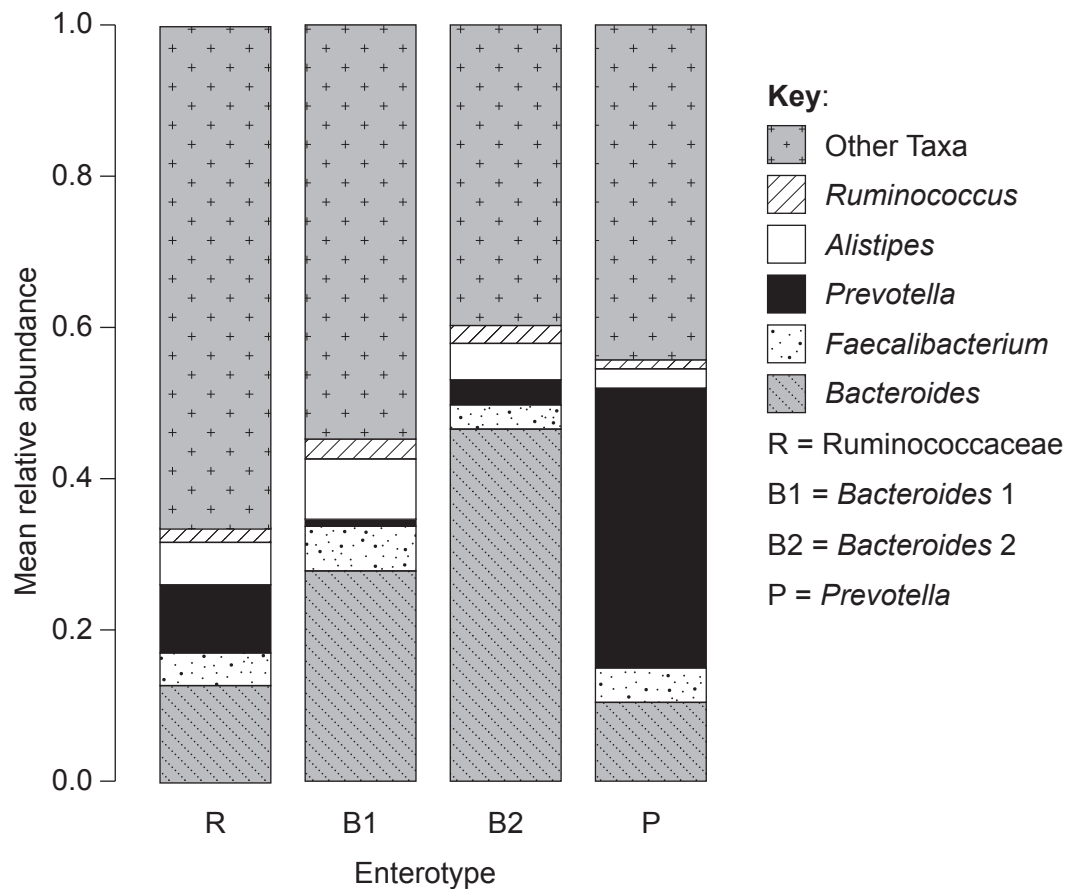


Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

- There is increasing interest in the bacteria that live in the human gut, known as the gut microbiota. Evidence is accumulating of widespread effects on human health, with some species of bacteria increasing the prevalence of specific diseases and others giving protection.

Long-term diet appears to influence the numbers and types of bacteria that are present in an individual's gut. Several different characteristic combinations of bacteria (called enterotypes) have been discovered. The stacked column graph shows relative amounts of different genera of bacteria in the gut of people with four of these enterotypes. The *Bacteroides* 2 (B2) enterotype is associated with an increased prevalence of inflammatory bowel disease.



[Source: Material from: Vieira-Silva, S., Falony, G., Belda, E. et al., Statin therapy is associated with lower prevalence of gut microbiota dysbiosis, published 2020, *Nature*, reproduced with permission of SNCSC.]

- Using the data in the stacked column graph, describe the features that characterize the B2 enterotype.

[2]

(This question continues on the following page)

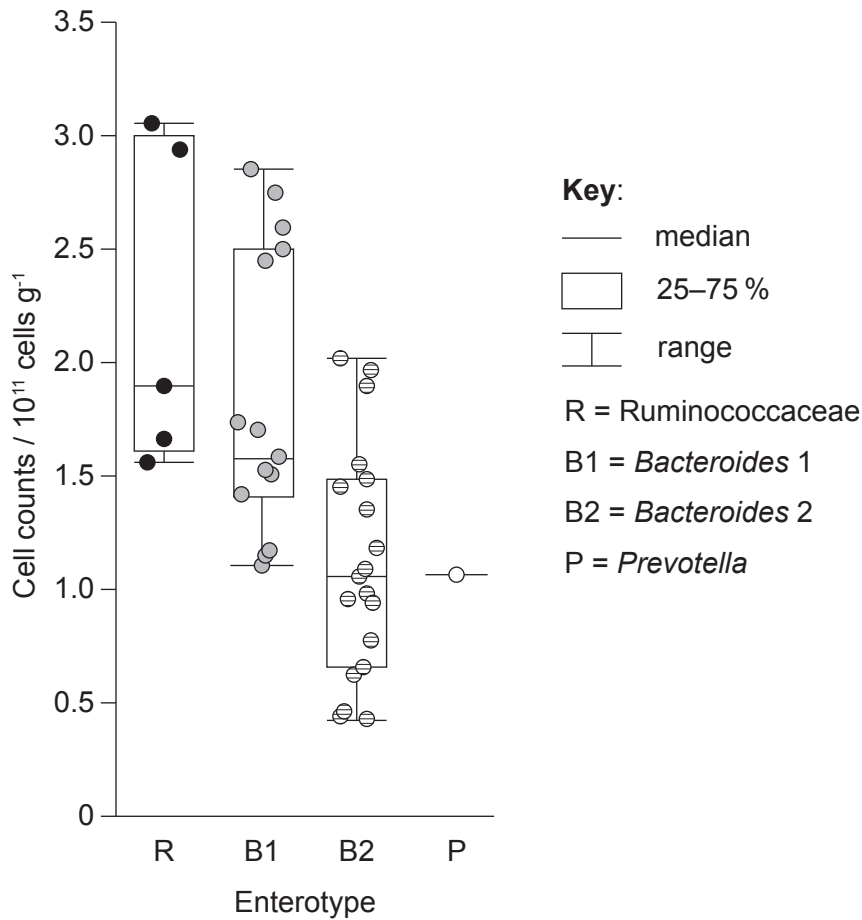


20EP03

Turn over

(Question 1 continued)

Samples of feces were collected from 40 individuals and were immediately frozen to preserve them. The numbers of bacteria in the feces (cell counts / 10^{11} cells g^{-1}) were later measured and the enterotype was determined. The box plot shows this data. Each data point shows the cell count from one fecal sample.



[Source: Material from: Vandeputte, D., Kathagen, G., D'hoel, K. et al., Quantitative microbiome profiling links gut community variation to microbial load, published 2017, *Nature*, reproduced with permission of SNCSC.]

(This question continues on the following page)



(Question 1 continued)

- (b) Estimate the median number of bacterial cells per gram of feces in the R enterotype. [1]

.....
.....

- (c) Distinguish between the cell counts in the R and B2 enterotypes. [2]

.....
.....
.....
.....

- (d) Comment on the data for the P enterotype. [1]

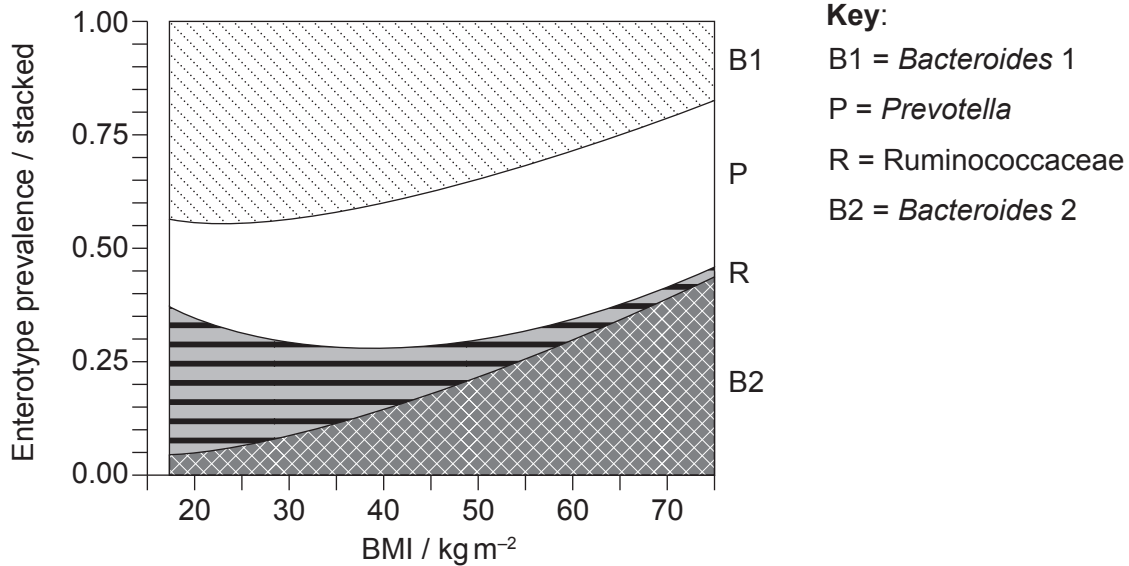
.....
.....

(This question continues on the following page)



(Question 1 continued)

Statins are drugs that are commonly prescribed to reduce cholesterol concentrations in the blood. As part of research into the effects of statins, the enterotype and body mass index (BMI) of 782 individuals were determined. The results are shown in the stacked graph.



[Source: Material from: Vieira-Silva, S., Falony, G., Belda, E. et al., Statin therapy is associated with lower prevalence of gut microbiota dysbiosis, published 2020, *Nature*, reproduced with permission of SNCSC.]

- (e) (i) Estimate the prevalence of the P enterotype at a BMI of 50. [1]

.....

- (ii) State the relationship between BMI and the prevalence of the B2 enterotype. [1]

.....

- (f) Evaluate the evidence provided by the data in the graph for the hypothesis that the R enterotype causes low BMI. [2]

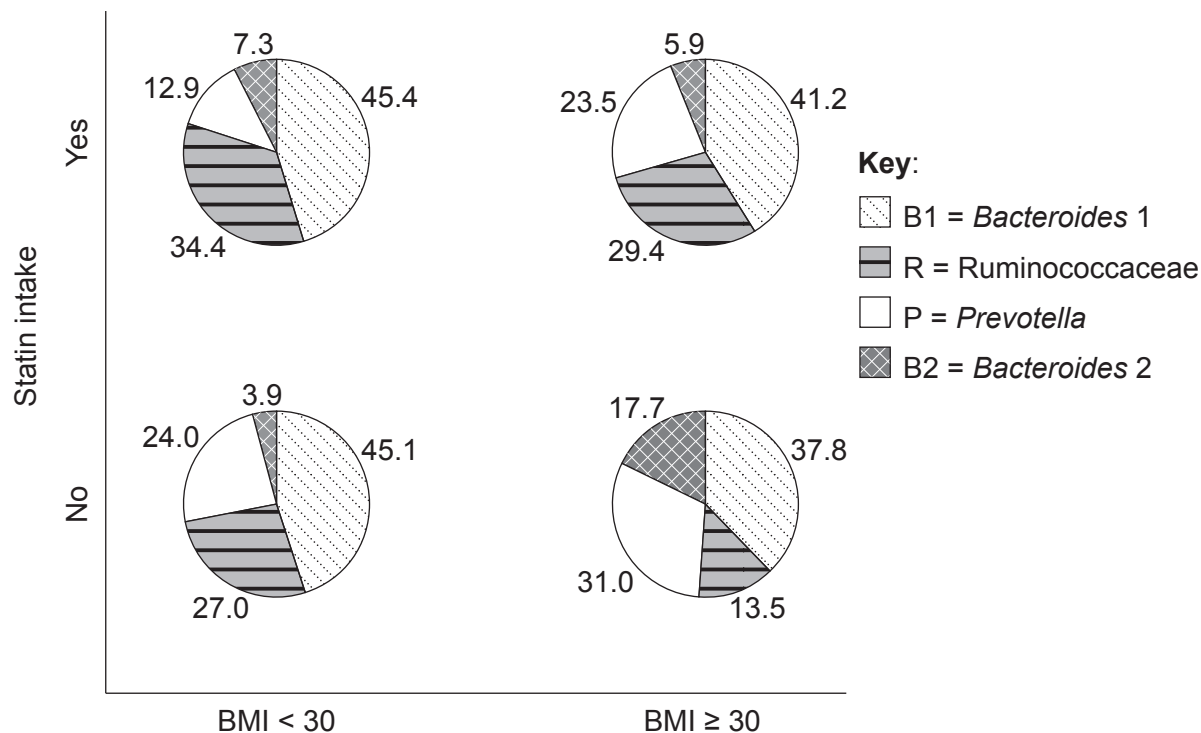
.....

(This question continues on the following page)



(Question 1 continued)

The 782 individuals for whom BMI and enterotype had been determined were divided into four groups, according to whether or not they were taking statins and their BMI category. The prevalence of the four enterotypes in each of these groups is shown as a percentage in the pie charts.



[Source: Material from: Vieira-Silva, S., Falony, G., Belda, E. et al., Statin therapy is associated with lower prevalence of gut microbiota dysbiosis, published 2020, *Nature*, reproduced with permission of SNCSC.]

- (g) The prevalence of inflammatory bowel disease rises with increases in BMI. At any BMI level, individuals with the B2 enterotype have a higher prevalence of inflammatory bowel disease than with other enterotypes. Using the data in the graph, discuss whether statins could reduce the incidence of inflammatory bowel disease.

[2]

.....

.....

.....

.....



2. The dolichos bean (*Lablab purpureus*) is cultivated as a food crop in tropical countries. Leaf cells in *L. purpureus* have 24 chromosomes.

(a) State how many chromosomes there would be in male or female gametes of *L. purpureus*. [1]

.....

L. purpureus can have purple or white flowers. Two pure-breeding varieties were crossed: HA 4 with white flowers and GL 424 with purple flowers. All of the F_1 plants had purple flowers. The F_1 plants were self-pollinated to produce an F_2 generation. There were 97 plants with purple flowers and 38 plants with white flowers in the F_2 generation.

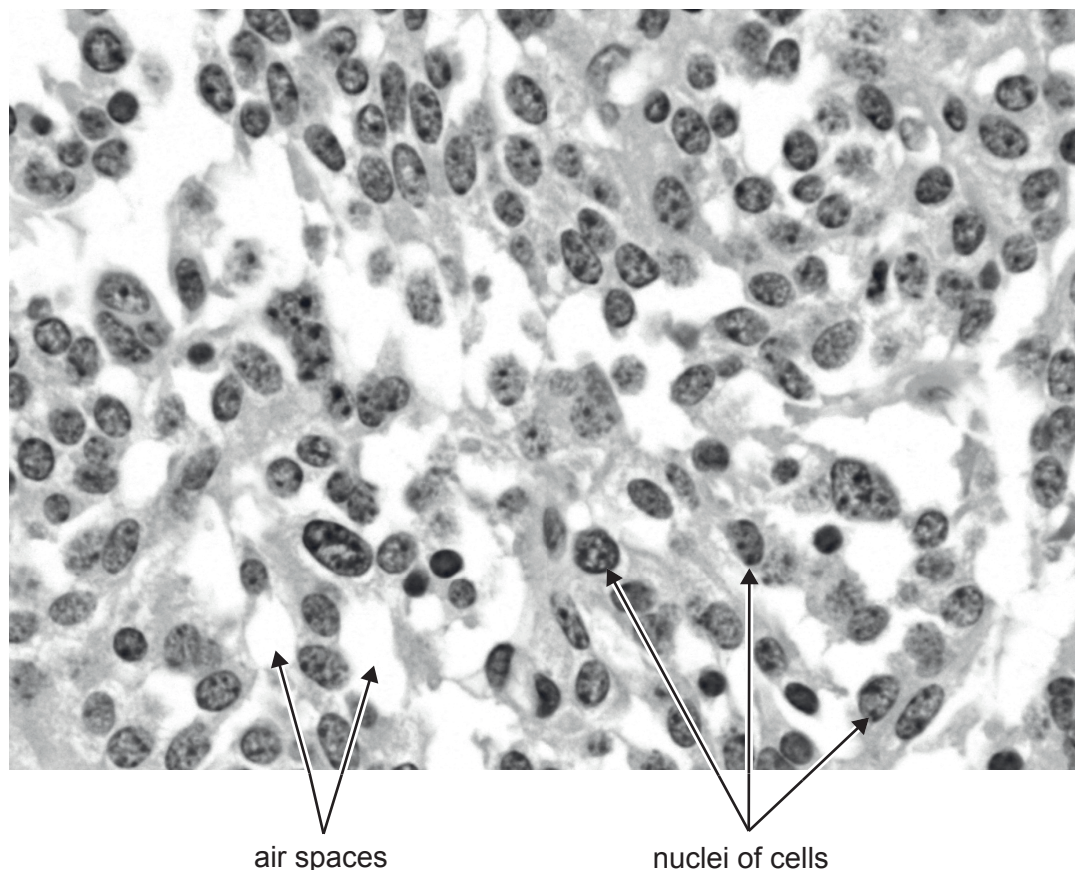
(b) Using a Punnett grid, explain the results of this cross. [3]

(c) Suggest a reason for the F_2 generation not corresponding exactly to the expected ratio of purple-flowered and white-flowered plants. [1]

.....



3. The light micrograph shows tumour tissue from a patient's lung.



- (a) State one cause of lung cancer.

[1]

.....

- (b) Suggest one difference between tissue taken from a lung cancer tumour and normal lung tissue that might be seen in micrographs.

[1]

.....

- (c) The lung tumour in the light micrograph was slow-growing. Predict with a reason what would have been visible in the micrograph if the tumour was growing rapidly.

[2]

.....



4. The Chinese pangolin (*Manis pentadactyla*) is a critically endangered species that has declined in numbers by 80 % since 2000. It inhabits both forest and grassland, where it uses long, powerful claws to open ant and termite nests and ingests the insects using a long, sticky tongue.



- (a) (i) State with a reason whether pangolins are autotrophic or heterotrophic. [1]

.....
.....

- (ii) Explain what information is needed to find the trophic level of pangolins. [2]

.....
.....
.....
.....

- (b) Outline evidence for evolution from the limbs of mammals such as pangolins. [2]

.....
.....
.....
.....

(This question continues on the following page)



(Question 4 continued)

- (c) The cladogram shows relationships between all living species of pangolin. The numbers on the cladogram indicate time in millions of years since divergence from a common ancestor.

Removed for copyright reasons

- (i) State how many genera of pangolin are recognized.

[1]

.....
.....

- (ii) Outline how times since divergence are estimated when cladograms are constructed.

[1]

.....
.....



5. The table shows thermal properties of water and methane.

Property	Freezing point / °C	Boiling point / °C	Heat capacity / J g ⁻¹ °C ⁻¹	Heat of vaporization / J g ⁻¹
Water (H ₂ O)	0	100	4.2	3357
Methane (CH ₄)	-182	-160	2.2	760

- (a) Water molecules are polar and methane molecules are non-polar. Explain how this difference affects the thermal properties of these substances.

[2]

.....

.....

.....

.....

- (b) Using the data in the table, deduce the reasons for methane being a gas on Earth.

[2]

.....

.....

.....

.....

- (c) Water is used as a coolant in sweat. Using the data in the table, explain the reasons for methane not being as suitable as water for use as a coolant.

[2]

.....

.....

.....

.....



Section B

Answer **one** question. Up to one additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

6. Between 1900 and 2020 the Earth's average surface air temperature increased by about 1° C. Temperature affects many biological processes.
- (a) Explain how temperature affects enzymes. [4]
 - (b) Outline the role of the thyroid gland in helping to control body temperature in humans. [4]
 - (c) Describe how human activities have caused average surface air temperatures on Earth to increase. [7]
7. Eukaryotes are classified into kingdoms, one of which is the animal kingdom.
- (a) Describe the organelles and other structures in animal cells that are visible in electron micrographs. [7]
 - (b) Explain how animal cells produce the ATP that they need. [5]
 - (c) Distinguish between reptiles and amphibians in terms of their recognition features. [3]



.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

- 1.a Material from: Vieira-Silva, S., Falony, G., Belda, E. et al., Statin therapy is associated with lower prevalence of gut microbiota dysbiosis, published 2020, *Nature*, reproduced with permission of SNCSC.
- 1.b Material from: Vandeputte, D., Kathagen, G., D'hoë, K. et al., Quantitative microbiome profiling links gut community variation to microbial load, published 2017, *Nature*, reproduced with permission of SNCSC.
- 1.e Material from: Vieira-Silva, S., Falony, G., Belda, E. et al., Statin therapy is associated with lower prevalence of gut microbiota dysbiosis, published 2020, *Nature*, reproduced with permission of SNCSC.
- 1.g Material from: Vieira-Silva, S., Falony, G., Belda, E. et al., Statin therapy is associated with lower prevalence of gut microbiota dysbiosis, published 2020, *Nature*, reproduced with permission of SNCSC.
- 2.b Material from: Keerthi, et al., Further evidence for the genetic basis of qualitative traits and their linkage relationships in dolichos bean (*Lablab purpureus* L.), published 2016, *Journal of Genetics*, reproduced with permission of SNCSC.
- 3. Nephron, 2012. Lung carcinoid – very high mag. [image online] Available at: https://commons.wikimedia.org/wiki/File:Lung_carcinoid_-_very_high_mag.jpg [Accessed 18 October 2021]. Public domain.
- 4. By U.S. Fish and Wildlife Service Headquarters - Manis pentadactyla, CC BY 2.0, <https://commons.wikimedia.org/w/index.php?curid=56589200>. Photo credit to Ms. Sarita Jnawali of NTNC – Central Zoo. The United States is co-sponsoring four separate proposals to increase CITES protections for pangolins from Appendix II to Appendix I, U.S. Fish and Wildlife Service Headquarters - Manis pentadactyla. CC BY 2.0. File:Manis pentadactyla (29054818144).jpg. Created: 14 September 2016.