

Zoology 300: Invertebrate Biology and Evolution

Location: Online only

Instructor: **Prashant Sharma**
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Office hours: Fridays 2-3 PM on BBCollab:

<https://zoom.us/j/94306821956?pwd=MmJPdUM0QnBNNEdrN0pKOVg0aFA2dz09>

Teaching Assistant: **Andrew Ontano (Zoology 300)**
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Office hours by appointment

3 credits (lecture)

Lectures: Tuesdays and Thursdays 11 AM-12:15 PM (posted by the morning of each class)

Grading (lecture)

40 pts	Weekly quizzes/assignments
25 pts	Midterm exam
35 pts	Final exam
<i>100 pts</i>	<i>Total</i>

Grading scale: A (93-100%), AB (87-92%), B (83-86%), BC (77-82%), C (70-76%), D (60-70%), F (<60%).

Overview

This course provides an introduction to invertebrate diversity and biology, with emphasis on anatomy, development, and systematic relationships of the main animal phyla. Phyla are discussed in the context of major themes in animal evolution, such as the origin of tissue layers, the diversity of feeding mechanisms, the evolution of terrestrialization, patterns of diversification through time, and the conservation of transcriptional circuitry. The aim of this course is to understand animal diversity from a phylogenetic and developmental perspective, and to develop analytical ability to interpret organismal diversity.

Prerequisites

Zoology 101/101, 151/152 or Biocore 381

Canvas URL: <https://canvas.wisc.edu/courses/244509>

Learning outcomes (Zoology 300)

By the end of this course, you will be able to:

1. describe the major macroevolutionary trends spanning animal evolution through the Phanerozoic
2. characterize the differences between animal phyla
3. interpret and analyze phylogenetic trees
4. predict and interpret the function of a gene from a gene regulatory network
5. interpret image data from biological samples

Readings

Mandatory textbooks: None.

Mandatory chapters/other readings:

1. **Brusca, R. C., Moore, W., and S. M. Schuster. 2016. Invertebrates, 3rd edition. Sinauer Associates, Sunderland. (Scanned chapters of this text will be made available online—you do not need to purchase anything for this class.)**
2. Selections from the primary literature (**PDFs will be posted on weekly module pages on Canvas.**)

Recommended textbooks: The following texts are strongly recommended as helpful resources and/or background reading.

- 1) Gilbert, S. F. and A. M. Raunio. 1997. Embryology: Constructing the Organism. Sinauer Associates, Sunderland.
- 2) Minelli, A. 2009. Perspectives in Animal Phylogeny & Evolution. Oxford University Press, Oxford.

Readings and lab materials

Course materials will be made available online on the course website, or the URLs are provided in this syllabus. Weekly readings should be completed by Thursday of each week.

Online quizzes/assignments

Online quizzes/assignments are issued on Canvas on Thursday afternoon of each week and are due the following Monday at 5 pm. These will generally be in multiple choice format.

Responses must be recorded by Monday at 5 pm; late submissions are not accepted.

There is one midterm exam and one final exam given in class, as indicated below in the lecture schedule. There are no makeup exams except in the case of medical emergency or religious obligation.

Office hours policy

The teaching staff is here to support your learning needs, including outside of class. If the available office hours do not fit your schedule, please schedule an appointment with us outside of those hours. I strongly recommend visiting office hours at least once during the semester to introduce yourself.

Most important reason for visiting office hours: Have questions about the readings and how they might be tested on the upcoming Monday quiz? Drop by and ask us about it. We can help.

Lectures

Tuesday, 26 January

Introduction and general concepts in invertebrate biology

- Course overview
- What are animals?
- Themes in metazoan diversity

Thursday, 28 January

The Cambrian Explosion

- Animal architecture and body plans
- The end of the Ediacaran biota
- Oxygen and anatomical complexity

Readings (recommended): Invertebrates, Chapter 4

Tuesday, 2 February

Systematics and tree thinking

- What does a phylogenetic tree tell you?
- Constructing phylogenies
- Characters, states, and costs

Readings (mandatory): Invertebrates, Chapter 2

Thursday, 4 February

Multicellularity and complexity

- Choanoflagellates
- Porifera: organization without nervous systems

Readings (mandatory):

Cepelewicz, J. 2019. *Scientists Debate the Origin of Cell Types in the First Animals*. Quanta Magazine. (URL: <https://www.quantamagazine.org/scientists-debate-the-origin-of-cell-types-in-the-first-animals-20190717>)

Readings (recommended): Invertebrates, Chapter 6

Tuesday, 9 February

Deep relationships and the root of Metazoa

- Cnidaria
- Ctenophora

Readings (mandatory):

Dunn, C. 2015. *Who is our most distant animal relative?* Medium.com (URL: <https://medium.com/@caseywdunn/who-is-our-most-distant-animal-relative-4309b9fe4e48#.o2dwexjy1>)

Readings (recommended): Invertebrates, Chapters 7-8

Thursday, 11 February

Bilateral symmetry, blastopores, and nephridia

- Further problematica: Placozoa and *Xenoturbella*
- Nemertodermatida
- Acoela

Readings (mandatory):

Rouse, G.W., Wilson, N.G., Carvajal, J.I., Vrijenhoek, R.C. (2016). New deep-sea species of *Xenoturbella* and the position of Xenacoelomorpha. *Nature* 530, 94-97.

Readings (recommended): Invertebrates, Chapter 9

Tuesday, 16 February

Annelids, segmentation, and spiral cleavage

Readings (mandatory):

Dray, N., Tessmar-Raible, K., Le Gouar, M., et al. (2010) Hedgehog Signaling Regulates Segment Formation in the Annelid *Platynereis*. *Science* 329, 339-342.

Readings (recommended): Invertebrates, Chapter 14

Thursday, 18 February

Principles of evo-devo and comparative development

Readings (mandatory): None.

Tuesday, 23 February

Mollusks I

Readings (mandatory):

Grande, C., Patel, N.H. (2009). *Nodal* signaling is involved in left-right asymmetry in snails. *Nature* 457, 1007-1011.

Readings (recommended): Invertebrates, Chapter 13

Thursday, 25 February

Mollusks II

Readings (mandatory):

Tarazona, O.A., Lopez, D.H., Slota, L.A., Cohn, M.J. (2019). Evolution of limb development in cephalopod mollusks. *Elife* 8:e43828.

Readings (recommended): Invertebrates, Chapter 13

Tuesday, 2 March

Platyhelminthes

Readings (mandatory):

Sikes, J.M., Newmark, P.A. (2013) Restoration of regeneration in a planarian with limited regenerative ability. *Nature* 500, 77-80.

Readings (recommended): Invertebrates, Chapters 10, 11

Thursday, 4 March

Orthonectida, Dicyemida, and Gastrotricha

Readings (mandatory):

Schiffer, P.H., Robertson, H.E., Telford, M.J. (2018) Orthonectids Are Highly Degenerate Annelid Worms. *Current Biology* 28, 1970–1974.

Readings (recommended): Invertebrates, Chapters 10, 11

Tuesday, 9 March

The lophophorate phyla I

- Phoronida
- Brachiopoda
- Bryozoa (Ectoprocta)
- Parametric analysis of diversification dynamics

Readings (mandatory):

Carlson, S.J. 2016. The Evolution of Brachiopoda. *Annual Review of Earth and Planetary Sciences* 44, 409–438 (**Sections 1-3, and 5.5 only**)

Readings (recommended): Invertebrates, Chapters 15, 17

Thursday, 11 March

The lophophorate phyla II

- Entoprocta (Kamptozoa)
- Cycliophora
- Interpreting population genetics

Readings (mandatory):

Baker, J.M., Funch, P., Giribet, G. (2007) Cryptic speciation in the recently discovered American cycliophoran *Symbion americanus*; genetic structure and population expansion. *Marine Biology* 151, 2183–2193.

Readings (recommended): Invertebrates, Chapters 15, 17

Tuesday, 16 March

Gnathifera

- Gnathostomulida
- Rotifera/Syndermata
- Micrognathozoa

Readings (mandatory):

Fröblius, A.C., Funch, P. (2017) Rotiferan Hox genes give new insights into the evolution of metazoan bodyplans. *Nat Communications* 8, 9.

Readings (recommended): Invertebrates, Chapter 16

Thursday, 18 March

Midterm exam

Tuesday, 23 March

Introduction to Ecdysozoa

- What are ecdysozoans?
- Ecdysone and molting
- Nematoda and Nematomorpha

Readings (mandatory):

Giribet, G., Edgecombe, G.D. (2017) Current Understanding of Ecdysozoa and its Internal Phylogenetic Relationships. *Integrative and Comparative Biology* 57, 455-466.

Readings (recommended): Invertebrates, Chapter 18

Thursday, 25 March

Scalidophora

- Kinorhyncha
- Priapula
- Loricifera

Readings (mandatory):

Martín-Durán, J.M., Janssen, R., Wennberg, S., Budd, G.E., Hejnol, A. (2012) Deuterostomic development in the protostome *Priapulus caudatus*. *Current Biology* 22: 2161-2166

Readings (recommended): Invertebrates, Chapter 19

Tuesday, 30 March

Introduction to Panarthropoda

- Tardigrada
- Onychophora

Readings (mandatory):

Smith, F.W., Boothby, T.C., Giovannini, I., Rebecchi, L., Jockusch, E.L., Goldstein, B. (2016). The Compact Body Plan of Tardigrades Evolved by the Loss of a Large Body Region. *Current Biology* 26, 224-229.

Readings (recommended): Invertebrates, Chapter 20

Thursday, 1 April

Introduction to Arthropoda

- The arachnid book lung
- The insect tracheal tubules
- The Malpighian tubule system

Readings (mandatory):

Ontano, A.Z., Gainett, G., Aharon, S., et al. (2021) Taxonomic sampling and rare genomic changes overcome long-branch attraction in the phylogenetic placement of pseudoscorpions. *Biorxiv* (<https://doi.org/10.1101/2020.11.18.389098>)

Readings (recommended): Invertebrates, Chapters 23, 24

Tuesday, 6 April

Arthropod diversity and diversification

- Detecting co-diversification using dated phylogenies
- Hyperdiverse groups

Readings (mandatory):

Linz, D.M., Tomoyasu, Y. 2018. Dual evolutionary origin of insect wings supported by an investigation of the abdominal wing serial homologs in *Tribolium*. *Proceedings of the National Academy of Sciences of the USA* 115, E658-E667.

Readings (recommended): Invertebrates, Chapters 21, 22

Thursday, 8 April

The diversification of Pancrustacea

- Insects and mouthpart evolution
- The origin of insect wings
- Hyperdiverse groups

Readings (mandatory):

Endara, M.-J., Coley, P.D., Ghabash, G., et al. (2017) Coevolutionary arms race versus host defense chase in a tropical herbivore–plant system. *Proceedings of the National Academy of Sciences of the USA* 114, E7499-E7505.

Readings (recommended): Invertebrates, Chapters 21, 22

Tuesday, 13 April

Arthropods in evodevo

- Hox genes
- The evolution of the mandible
- Reconciling development and phylogenetics

Readings (mandatory):

Setton, E.V.W., Sharma, P.P. (2018) Cooption of an appendage-patterning gene cassette in the head segmentation of arachnids. *Proceedings of the National Academy of Sciences of the USA* 115, E3491-E3500.

Readings (recommended): Invertebrates, Chapters 21, 22

Thursday, 15 April

New axes of symmetry

- Chaetognatha
- Echinodermata

Readings (mandatory):

Telford, M.J., Lowe, C.J., Cameron, C.B., Ortega-Martinez, O., Aronowicz, J., Oliveri, P., Copley, R.R. (2014). Phylogenomic analysis of echinoderm class relationships supports Asterozoa. *Proceedings of the Royal Society B: Biological Sciences* 281, 20140479.

Readings (recommended): Invertebrates, Chapters 11, 25

Tuesday, 20 April

The journey of the notochord

- Hemichordata
- Urochordata
- Cephalochordata

Readings (mandatory):

Li, G., Liu, X., Xing, C., Zhang H., Shimeld, S.M., Wang, Y. (2017). Cerberus–Nodal–Lefty–Pitx signaling cascade controls left–right asymmetry in amphioxus. *Proceedings of the National Academy of the USA* 114, 3684-3689

Readings (recommended): Invertebrates, Chapters 26, 27

Thursday, 22 April

Deep homologies and integration of data classes

Readings (mandatory):

Cavalier-Smith, T. (2016). Origin of animal multicellularity: precursors, causes, consequences—the choanoflagellate/sponge transition, neurogenesis and the Cambrian explosion. *Phil. Trans. R. Soc. B.* 372:20150476.

Tuesday, 27 April

Final exam review

Thursday, 29 April

Final exam