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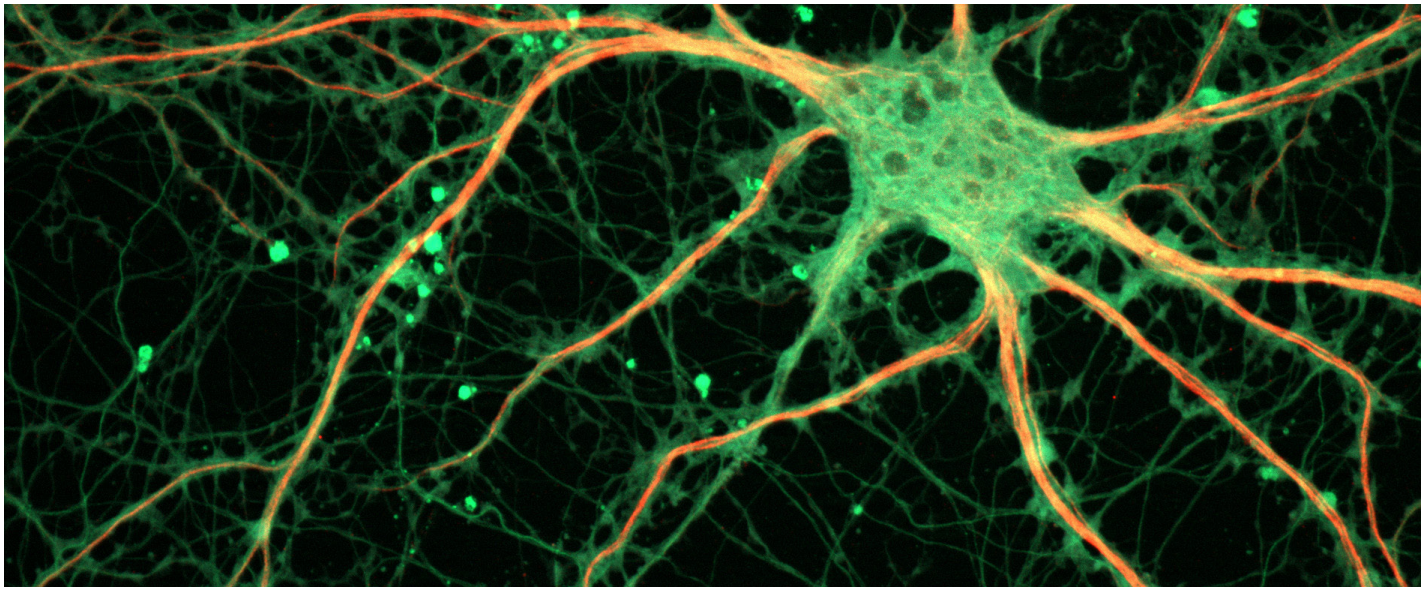

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Hold your nerve: acting out chemical synaptic transmission

Matthias Andersen-Gassner, Andrea Möller

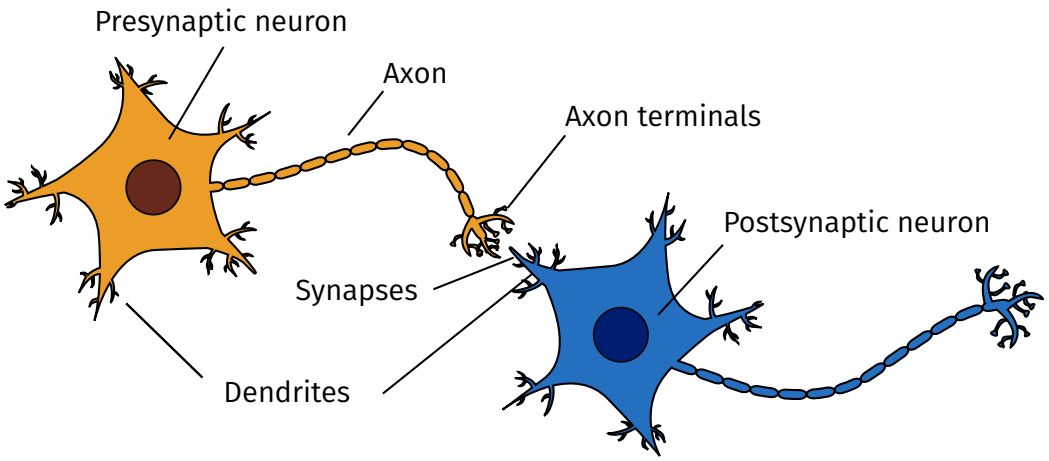
Play the part: students take on the roles of different components of a synapse to act out synaptic transmission and learn about neurobiology.

Teaching neurobiology to students can often be challenging. In fact, neurophysiological topics are some of the most difficult concepts that students and teachers in school are confronted with. With topics this complex, many teachers tend to switch on 'here are the facts, just memorise them' mode. For that, we use textbooks, in which the electrochemical processes are reduced to a mere list of numerous steps, often accompanied by figures with overwhelming complexity. In the activity presented here, students take on the roles of different components of a synapse to act out synaptic transmission.

It is generally accepted that active learning increases students' motivation and leads to better performance in various scientific disciplines.[1,2] Moreover, moving around in a classroom, taking part in a role play involving interactions with other students, can enhance the level of activity to the point where students are, in general, more attentive.[3]

This activity allows teachers to differentiate between students who need more guidance and those already familiar with active teaching methods. It is a valuable way to investigate synaptic transmission alongside the classic learning track and can be easily incorporated into a traditional teaching unit with hardly any additional costs.

Parts of a neuron



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Synapse role play

The hands-on activity outlined here is suitable for students aged 14–19 and adaptable for a group of 10–18 students. With more students, split them into two groups.

Students will need approximately 10–15 min for the introduction (this can also be set as homework) and 40 min for the rest of the task.

At the end of the activity, students are encouraged to save their results by producing a short video of their synaptic model role play.

Materials

- Table tennis balls (around 50 per group) divided into 2 boxes
- Synaptic transmission infosheet
- Level 1 acting cards, level 2 role labels, or blank cards
- Synaptic transmission diagram
- Binder clips or clothes pegs for fixing cards onto students' clothing
- Synapse labels for the pre- and postsynaptic neurons
- Two short ropes (approx. 3 m) to mitigate the synaptic cleft
- Misconception cards for students
- Smartphone capable of recording a short movie

The activity cards can be provided at three complexity levels to make the activity adaptable to different student ages and abilities.

Table 1: Complexity levels of the supporting material

Complexity level	Supporting material
Level 1 (easy)	Acting cards with a short description (the number of acting cards is already fixed) plus the synapse diagram
Level 2 (medium)	Role labels without description
Level 3 (difficult)	Blank acting cards to be filled out by the students

Materials used for the activity
Image courtesy of the authors

Procedure

1. Ahead of the activity, students should be given a short introduction to the topic of chemical synaptic transmission. This introduction can also be done in a flipped classroom format, where the students read an article about synaptic transmission at home (such as the synaptic transmission infosheet) or watch a short movie about synaptic transmission.
2. Establish a clear space in your classroom or outside (approx. 15 m^2 per group).
3. Divide the students into groups, with a minimum of 10 and a maximum of 18 students. Note that larger groups of students will probably need more guidance from the teacher.
4. Inform the students that they will be acting out what happens when two neurons communicate via a chemical synapse.
5. Hand out the table tennis balls in a box (around 50 balls per group/two boxes) and two ropes per group. The ropes can be used to delineate the synaptic cleft.
6. Each table tennis ball acts as one molecule of neurotransmitter.
7. Hand out the acting cards, role labels, or blank cards, depending on the degree of students' subject knowledge and their ability to work without guidance (table 1). Roles should be assigned and cards should be clipped to students' clothing like a badge, so that everybody knows each other's role in the group.

> The following characters are on stage:
> 1. Plasma membrane
> 2. Action potential
> 3. Ca^{2+} channel
> 4. Vesicle
> 5. Ions
> 6. Ion channel
> 7. Receptor/ion channel
> 8. Neurotransmitter-degrading enzyme
> 9. Neurotransmitter-reuptake transporter

8. Now the students are instructed to act out the process of synaptic transmission, according to what they have learned in the introduction part.
9. After about 20 min, ask the students to explain their model of synaptic transmission.
10. The teacher can help to unravel possible misconceptions (table 2) and identify deficits that emerge during the performance. For example, the table tennis balls are intentionally moved rather than diffusing and finding a receptor by chance. If misconceptions occur, use the appropriate cards from supporting material 5 and hand them out to the students for discussion.

Table 2: Possible misconceptions of students and corresponding supportive cards

Misconception card	Misconception
M1	The neurotransmitters (table tennis balls) are thrown on target
M2	The receptor/ion channel catches the neurotransmitter
M3	The neurotransmitter binds permanently to the receptor
M4	The vesicles stay in the synaptic cleft
M5	The neurotransmitter stays permanently in the synaptic cleft
M6	The neurotransmitter-degrading enzymes are only active at the end of the role play (after the neurotransmitter has bound to the receptor)

11. After working with the cards, the model should be more and more precise, and students should understand the underlying concepts of synaptic transmission.

12. One of the students should record a suitable final version of the performance on a smartphone as a short movie.
13. The students should write an accompanying text on their process to provide a synchronised narration for the short movie. This can be used to check students' acquired knowledge and detect common misconceptions and/or grade the work.

One possibility of acting out the process of chemical synaptic transmission

Image courtesy of Matthias Andersen-Gassner

Discussion

It is important that students understand the model they have created and that any misconceptions are discussed during the process of acting out synaptic transmission. The social dialogue between the students and teacher should also be a focus.

Conclusion

A substantial body of literature has demonstrated that the application of nonconventional approaches, such as games and role play, stimulates learning.[2–5] We recommend that during the performance students work on their own and teachers try not to interfere at all. It is important that all students are familiar with the topic before they start the role play. Otherwise, the role play tends to end in confusion.

Finally, the created videos can be used as a template for several follow-up lessons dealing with drugs, diseases, or the concept of inhibitory and excitatory synapses. «

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Resources

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- Explore chemotaxis and the scientific method with slime mould experiments: Buchta A, Dunthorn M (2023) Moving slime: exploring chemotaxis with slime mould. *Science in School* **62**.
- Study toxicology and the physiological effects of drugs using Daphnia as a model organism: Faria HM, Fonseca AP (2022) From drugs to climate change: hands-on experiments with Daphnia as a model organism. *Science in School* **59**.
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- Explore how research projects are chosen for funding with this role-playing activity: McHugh M et al. (2021) What is it good for? Basic versus applied research. *Science in School* **55**.

AUTHOR BIOGRAPHY

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