

Honeybee Democracy

Suitable Grade Levels: 9th-12th

Time: 30 - 60 min

Prerequisites:

Students should be familiar with the basic biology and social organization of honey bees.

Materials:

- Video: What Honeybees Can Teach Us About Democracy.
<https://www.youtube.com/watch?v=abk-advclw>
- Video: Swarm Intelligence with Tom Seeley.
https://www.youtube.com/watch?v=1x8T_CHZemE
- Video: Honeybee Decision Making.
<http://www.cornell.edu/video/honeybee-decision-making>

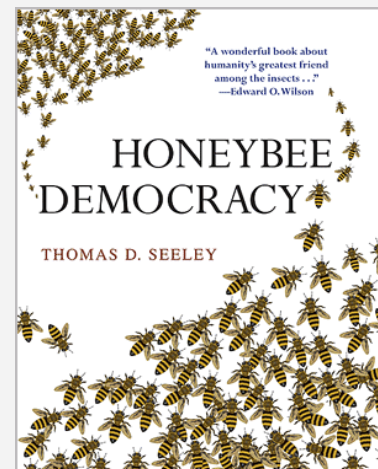
Related content:

- [Life in groups and conflict](#)
- [Exploring design principles for cooperation](#)

Lesson Overview

The biologist Thomas Seeley has been researching the behavior of honeybees. Particularly, he has been interested in the decision making processes that allow honeybee colonies to reliably choose among the best quality sites in an area for their new home. In his book "Honeybee Democracy", he describes how these decision making processes work, identifies a number of principles, and makes an analogy between decision making in bees and human groups (as the title of the book suggests!). This work helps us understand the challenges and mechanisms of a group of individuals having to make group-level decisions without a leader.

In this lesson, students explore how honey bees make their collective decisions, link these processes to general principles, and critically transfer and compare them to decision making in human groups.



Learning goals

Competencies: Cooperation Competency, Evaluation Competency, Evolutionary Thinking, Systems Thinking, Interdisciplinary Thinking, Design Thinking

Understandings

Students are able to:

- understand the function of collective decision making in social species;
- understand that when a group of individuals have to make decisions together, it is advantageous if they share a common goal, if there is a diversity of independent experiences and viewpoints, if there is honest communication and exchange of viewpoints, if individuals agree or disagree with others based on their own observations, and if there is a decentralized election process with low influence of a leader.

Learning objectives and skills:

Students are able to:

- explain the importance of shared decision-making in the evolution of social species;
- compare the conditions and behaviors in the decision making process of a honey bee colony with the conditions and behaviors in the decision making process of human groups with the help of analogy maps;
- relate generalized principles of collective decision making to specific mechanisms of collective decision making with the help of analogy maps;
- to evaluate what actions human groups could take to make their decision-making process more democratic.

Concepts

collective decision making, shared goals, democracy, decentralized, variation, selection, adaptation, function, cooperation, *swarm intelligence*

Essential questions

- When a group of people have to agree on rules together, what challenges might this pose?

- What is *democracy*? How would you define it? What are important elements of a democracy?
- What is the importance of a democratic system of decision making in the sustainable development of a community?

Connections to Curriculum Standards

Next Generation Science Standards (NGSS)

Disciplinary Core Ideas: LS2.A: Interdependent Relationships in Ecosystems; LS2.D: Social Interactions and Group Behavior; LS4: Biological Evolution: Unity and Diversity

Suggested Lesson Plan

This lesson plan contains a variety of possible activities and content on the subject. Omit and prioritize activities based on available time and learning goals.

Phase	Materials	Questions
Initial Reflection (group discussion)		When a group of people have to agree on rules together, what challenges might this pose? What is <i>democracy</i>? How would you define it? What are important elements of a democracy? What is the importance of a democratic system of decision making in the sustainable development of a community?
Introduction to honeybees and their decision making challenge, brainstorming ideas	see below	How do you think honeybees are so good at making the best decision about their future nesting site? How do they do it?
Comparing decision making in honeybees and human groups	see below	

Optional: Criticism of the “honeybee democracy” analogy	see below	
Principles of collective decision making	see below	
Optional: Reflection questions on the function of the principles	see below	
Transfer to everyday experience and society	see below	
Reflection on conceptual understanding	see below	What is <i>democracy</i>? How would you define it? What are important elements of a democracy? What is the importance of a democratic system of decision making in the sustainable development of a community?

Decision making in honey bees

Honey bees are a species of bees that live in large colonies of thousands of individuals. A honey bee colony consists of one or a few queens, a few hundred male drones, and thousands of female worker bees. Every year in the spring, a part of a honey bee colony (consisting of a queen and thousands of worker bees) leaves the original colony to find a new nesting site in the area - this is called Swarming. Suitable sites for honey bee nests have to be large enough to accommodate the swarm, well protected from the elements, have a small entrance, and receive a certain amount of warmth from the sun. Biologists have found, through experiments, that the swarm finds the best quality nesting site in their area with remarkable accuracy - e.g. up to 99 % of the time.

How is the swarm of bees able to do this? Brainstorm ideas in your group. Think about the possible roles of the queen and the workers, of communication, or other behaviors of the bees.



Fig. 1: A swarm of honey bees, waiting to fly to their new nesting site.

(Source: Sichy007, [CC BY-SA 3.0](#))



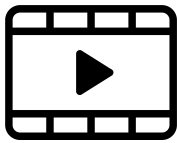
Fig. 2: A swarm of bees flying to their new site.
([Source:](#) Zantastik, [CC BY-SA 3.0](#))

Analogy between bees and human groups

How do the bees make their decisions about the future nesting site, and how does the decision making process of bees compare to how human groups make decisions?

Do human groups operate under the same conditions and have the same behaviors as bees when it comes to making a good collective decision, or are there important differences?

Use the resources below (videos, text excerpts) and discuss in your group to fill in the [analogy mapping table](#) below.



Videos:

- What Honeybees Can Teach Us About Democracy.
<https://www.youtube.com/watch?v=abk-advC1w>
- Swarm Intelligence with Tom Seeley.
https://www.youtube.com/watch?v=1x8T_CHZemE
- Honeybee Decision Making.
<http://www.cornell.edu/video/honeybee-decision-making>

Excerpts from Seeley (2010):

"The bees demonstrate to us several principles of effective group decision-making and (...) by implementing them we can raise the reliability of decision making by human groups."

"The house-hunting bees exemplify a group whose members have shared interests and mutual respect ... the genetic success of each worker bee in a honeybee colony depends on the fate of the entire colony The humans in a community rarely share a singularity of purpose like the bees in a swarm, so humans are less inclined than bees to be highly cooperative when tackling a problem they must address together."

"the swarm bees choose their new home without a leader integrating information from different sources or telling the others what to do. Even the all-important queen, who is certainly the genetic heart of a swarm, is merely a bystander.....Unlike honeybee swarms, most human groups operate with a leader. So clearly, a prominent question we must address is how the leader of a decision-making body should behave to promote sound thinking by the group."

"[bees] have just one problem to solve (so there is no confusion about their objective and no tendency for their discussion to drift off topic) and by the way they have rules of procedure that are hardwired into their nervous systems (so there is no need for someone to define or enforce their rules of procedure). Thus the house-hunting bees remind us that the leader in a democratic

group serves mainly to shape the process, not the product, of the group's deliberations. The bees also demonstrate that a democratic group can function perfectly well without a leader if the group's members agree on the problems they face and on the protocol they will use to make their decisions."

"perhaps most impressive about the bees' system of social choice is its ability to distinguish good options from bad ones so that almost always a swarm selects the single best site from among the dozen or more possible homesites that its scout bees have discovered."

"No scout bee, not even one that has encountered a wildly exuberant dancer, will blindly follow another scout's opinion by dancing for a site she has not inspected. This is critical...A scout will copy the dance that informed her of a site, but only after she has scrutinized the site herself and has concluded it truly deserves to be promoted. Thus the scout bees make use of the power of communication to help good ideas spread."

"How can humans use what the bees have demonstrated about aggregating the knowledge and opinions of a group's members to make good choices for the group as a whole? I suggest three things. First, we use the power of an open and fair competition of ideas, in the form of a frank debate [...] Second, we foster good communication within the debating group, recognizing that this is how valuable information that is uncovered by one member will quickly reach the other members. And third, we recognize that while it is important for a group's members to listen to what everyone else is saying, it is essential that they listen critically, form their own opinions about the options being discussed, and register their views independently."

"This debate works much like a political election, for there are multiple candidates (nest sites), competing advertisements (waggle dances) for the different candidates, individuals who are committed to one or another candidate (scouts supporting a site), and a pool of neutral voters (scouts not yet committed to a site)."

"each scout bee makes her own, independent decision of whether or not to support a site, based on her own, personal evaluation of the site, not on how others judge the site. Thus the bees aggregate the information about their options by conducting an open debate in which the best site prevails by virtue of its superiority, as judged time and time and time again by dozens, if not hundreds, of independent-minded scout bees."

"Over this vast stretch of evolutionary time, natural selection has structured these insect search committees so that they make the best possible decisions. Now, at last, we humans have the pleasure of knowing how this ingenious selection process works, and the opportunity to use this knowledge to improve our own lives."

Analogy Table

Note to teacher: Scaffold this task by filling out a few elements with the whole class, assigning sections of the table to different student groups, or providing a word bank

Decision making in a honey bee colony	Decision making in human groups
Communication through waggle dance	<i>Language (symbols, words, gestures, body language...)</i>
There is strong cooperation among all the bees, because all bees have a shared goal and purpose.	<i>Often less strong cooperation, competition between group members because of different individual interests or unclear group purpose</i>
The bees have one clearly defined "life-or-death" problem to solve.	<i>Often no clearly defined problem or several problems with trade-offs (so-called wicked problems)</i>
There is a clearly defined "best" solution among the options (a clear relationship between site quality and type of waggle dance for all bees)	<i>Often no clearly defined "best" solution (no clear relationship between theoretically best solution and individual opinions, humans are influenced by emotions, cognitive biases, experiences, values, group bias, short-term interests, norms)</i>
The decision making procedure is hard-wired into the nervous system of bees.	<i>Decision making procedures are cultural artifacts and influenced by emotions, values and morals, experiences, social norms, traditions, etc. The different systems for democratic elections in different countries are an example.</i>
The decision making process is the result of a 30 Mio year old evolutionary history, and adapted to environmental conditions that haven't changed much over 30 Mio years.	<i>A drastically changed social and natural environment compared to the majority of the evolutionary past of humans. Especially the rapid increase in group sizes within a few thousand years required culturally developed mechanisms and rules for collective decision making. Today's decision making processes in groups/nations may not always function well and have not necessarily stood the test of time, so they need to be continuously evaluated and improved upon.</i>

The bee swarm decides without the influence of a leader.	<i>In human groups there is often a leader who influences the decision making process (sometimes unconsciously) and this can have positive or negative effects on the group decision.</i>
Bees can evaluate proposed sites for themselves before making a decision.	<i>There is limited possibility for humans to evaluate the superiority of one proposed solution over another before making a decision. Humans often have to trust the honesty of statements others make. This can be exploited especially when there are conflicting interests (more or less purposeful spreading of false or misleading information). Humans often decide on the superiority of a solution based on moral intuitions, or based on what the majority of people around them think (→ link to norm psychology) which can hinder an unbiased and flexible view of the matter.</i>
Any other similarities and differences between honey bee decision making and decision making in human groups?	

Criticism of the “honeybee democracy” analogy

In the following text, an author criticizes Thomas Seeley’s analogy of a “honeybee democracy”.

“Honey bee democracy” has little to do with democracy. [...]

First, there is already the fact that the book suggests that the entire swarm of bees makes the decision on the location of the new hive, but in fact only the scout bees decide among themselves. These are quite a few hundred individuals, but that is just a small fraction of the entire swarm. So one cannot also not speak of a unanimous decision in the entire swarm.

And the decision of the scouts is also not entirely unanimous. In the end, although the best possible site usually wins, it is not chosen because a unanimous or even a majority number of bees voted for the site. Rather, the decision is made as soon as a necessary quorum of advertising scouts has votes for one location.

But I have serious doubts if a quorum decision would be beneficial for our democracy. This could put the reins in the hands of a dedicated minority, which may in all likelihood be radical in some way, in order to rule a (unfortunate) silent majority at will.”

(Source not available on the internet anymore, own translation from German)

How do you evaluate these criticisms? Do you find them justified? Does the author of this critique make a correct comparison between the decision-making process of bees and humans? Include the findings from the analogy table in your assessment.

It can be pointed out that the bee decision-making process relies on the existence of a unique common goal of all bees, as well as the fact that each scout bee can directly inspect the quality of alternative nesting sites. Thus, only a relatively small proportion of scout bees is enough (something like “deputies”, representatives) to make the best decision for the entire bee colony. That these principles are often absent in human groups is emphasized by Seeley. His aim is to point out these problems in human decision-making processes. So if a “small minority”, or even a small group of government deputies, are not pursuing the same or even conflicting goals as the entire group, then you can not expect that they will always make the best decisions in the group's interest.

Thus, this criticism does not seem to contradict the statements of Thomas Seeley. Rather, the author of this critique did not thoroughly reflect the principles and conditions of the honey bees' decision-making process in his critique, and incorrectly transferred them to humans.

Principles of collective decision making

Thomas Seeley has identified a number of principles that, according to him, allow a honeybee colony to collectively find the best home site in the area.

In the table below, match the described mechanisms and behaviors of decision making within a bee colony with the general principles.

List of principles

- Polycentric and inclusive decision making (meaning there is no strict top-down but rather a distributed decision-making system)
- Alignment of interests and a shared purpose
- Reliable transmission of information
- Selection based on continuous testing and verification in the environment
- Variation and diversity

List of mechanisms (extracted from Seeley, 2010)

- A swarm sends out hundreds of scout bees that explore for potential homesites...the house-hunting process of a honeybee swarm is open to the widest possible array of choices, and this gives the bees a strong start in selecting the best available living quarters.
- The swarm bees' decision-making process is a perfectly democratic endeavor, one in which the power is evenly diffused among all the scout bees in a swarm.... the swarm bees choose their new home without a leader telling the others what to do.
- The genetic success of each worker bee in a honeybee colony depends on the fate of the entire colony; no individual bee succeeds unless the whole colony survives and reproduces.
- each [bee] one decides whether to advertise a site, and if so how strongly, based on her own, independent evaluation of the site.
- The scouts operate interdependently in that they communicate with one another about their swarm's options....the better the site, the stronger the dances advertising it, hence the greater the positive feedback for this site.

Principles	Mechanisms and behaviors in honeybee colonies
Variation and diversity	<i>A swarm sends out hundreds of scout bees that explore for potential homesites...the house-hunting process of a honeybee swarm is open to the widest possible array of choices, and this gives the bees a strong start in selecting the best available living quarters.</i>
Selection based on continuous testing and verification in the environment	<i>each [bee] decides whether to advertise a site, and if so how strongly, based on her own, independent evaluation of the site.</i>
Alignment of interests / a shared purpose	<i>The genetic success of each worker bee in a honeybee colony depends on the fate of the entire colony; no individual bee succeeds unless the whole colony survives and reproduces</i>
Polycentric and inclusive decision making (meaning there is no strict top-down but rather a distributed decision-making system)	<i>The swarm bees' decision-making process is a perfectly democratic endeavor, one in which the power is evenly diffused among all the scout bees in a swarm.... the swarm bees choose their new home without a leader telling the others what to do.</i>
Reliable transmission of information	<i>The scouts operate interdependently in that they communicate with one another about their swarm's options....the better the site, the stronger the dances advertising it, hence the greater the positive feedback for this site.</i>

Reflections on the (evolutionary) functions of these principles

Why are these principles, and the respective mechanisms in a honey bee swarm, so important in the collective decision making of this species? Think about what might happen to a bee swarm in which one of the principles/mechanisms is not present or is different. Would the bees in the swarm be able to survive and reproduce just as well as those in the other bee swarms?

Principles	Consequences if principle is not present
Variation and diversity	If a bee swarm sent out less scout bees than other swarms, or only a few scout bees, then... <i>they might not find the best nesting site in the area, and the better nesting sites would be found by the other swarms. The nesting sites that they find would not favor survival and reproduction as much. Over generations, this swarm might get smaller and smaller and die out.</i>
Selection based on continuous testing and verification in the environment	If the scout bees in a bee swarm did not decide on the quality of a site based on their own independent inspection of the site, then <i>they might decide on a nesting site not because of its quality but because some bee or a few bees just happen to find it and advertise it. The nesting sites that they find would not favor survival and reproduction as much. Over generations, this swarm might get smaller and smaller and die out.</i>
Alignment of interests / a shared purpose	If the bees in a swarm did not have a shared goal (e.g. because they don't depend on each other for their reproduction), then.... <i>the swarm might end up splitting up into smaller units, with bees going into different nesting sites. It would be a different species with a different social organization.</i>
Polycentric and inclusive decision making (meaning there is no strict top-down but rather a distributed decision-making system)	If only one bee (e.g. the queen) in a swarm was to dictate the future nesting site, then <i>there might be a chance that sooner or later, the one bee "gets corrupted" due to some mutation or other factor, and the decision of that bee leads the whole swarm into a bad nesting site. This swarm could then die out.</i>

Reliable transmission of information	If the scout bees in a swarm were to do waggle dances that do not accurately communicate the quality of a site, then ... <i>they would not be able to communicate the quality of nesting sites accurately and the bees would constantly be visiting nesting sites that do not correspond to what they were communicated. It would greatly hinder the group decision making process, and they would not find the best nesting site as efficiently. It would take more resources and time compared to swarms where information is transmitted accurately.</i>
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Transfer to everyday experience and to society

1. Do you belong to a group that needs to make important decisions together? Think of sports teams and clubs, your class, your school, your family. Does this group have specific rules on how to make joint decisions? How does decision-making in the group compare to decision-making in a honeybee colony? What are the similarities and differences? Could the rules or common behaviors of decision-making in the group be improved?

2. What rules are there for political elections in your country? How does democratic decision-making in your country compare to decision-making in a bee colony? What are the similarities and differences? Could the rules for decision-making in your country be improved?

Reflection on conceptual understanding

What is *democracy*? How would you define it? What are important elements of a democracy? *Use evidence from this lesson on decision making in honey bees and human groups. Compare with your ideas at the beginning of the lesson.*

What is the importance of a democratic system of decision making in the sustainable development of a community?

Use evidence from this lesson on decision making in honey bees. Compare with your ideas at the beginning of the lesson.

References

Seeley, T. D. (2010). Honeybee Democracy. Princeton, New Jersey, USA: Princeton University Press.

Seeley, T. D., Visscher, P. K., & Passino, K. M. (2006). Group decision making in honey bee swarms. American Scientist, 94(3), 220–229.

<https://www.americanscientist.org/article/group-decision-making-in-honey-bee-swarms>

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<http://openevo.eva.mpg.de>



This material was developed in collaboration with the department of Comparative Cultural Psychology at the Max Planck Institute for Evolutionary Anthropology.



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