What makes a good environment for fungi? How do fungi make a good environment for us?

Secondary: (ages 11-14)	**Science**

In this unit, students learn about fungi and investigate what conditions make a good environment for fungi. Students create their own investigations to assess the best way to grow fungi, looking at factors such as temperature, materials and moisture and attempting to grow fungi under different conditions, making predictions about how the conditions will affect growth. Students gather data from texts and media to summarise information about the presence and impact of fungi on our environment, including their part in carbon sequestration. They revise their predictions to reflect the information they have collected. Finally, they design a fungi owner's manual to help another person grow fungi.

Time allocation	About 12 lesson periods
Subject content	eukaryotic organisms, Fungi, carbon sequestration, climate change
Creativity and critical thinking	This unit has a **creativity** and **critical thinking** focus: • Design personally novel investigations of the needs of a specific, "strange" organism, design an environment that suits those needs, and produce a manual to teach others. • Consider the organism in the larger ecological context and model how it affects biological systems and climate.
Other skills	Collaboration; Communication
Key words	mould, symbiosis, hyphae, carbon, fruit, spores, environment, carbon

Products and processes to assess

Students put together investigation plans with predictions for what they will find out. They carry out the plans, and develop a model of how the fungi grows. Students gather data from all the investigations in the classroom and write a claim with evidence and reasoning about the conditions that enable the growth

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of fungi. They work with their small group to write a fungi owner's manual. The final artefact, the students' fungi grower's manual, includes and synthesises the information gained from a neighbourhood exploration, the investigation, and text and media about the effect of fungi on the environment. At the highest levels of achievement, their work process shows an interest in exploring organisms they may previously have overlooked, and an increasing understanding of the complexity of the natural world as well as being highly imaginative. They are willing to gather information from a variety of sources, including their own investigations, consider other perspectives, and revise their thinking based on those explorations. Their final project shows an awareness of their audience and is both accurate and engaging.

Teaching and Learning plan

This plan suggests potential steps for implementing the activity. Teachers can introduce as many modifications as they see fit to adapt the activity to their teaching context.

Step	Duration	Teacher and student roles	Subject content	Creativity	Critical thinking
1	Lesson periods 1 and 2	**What are fungi?** Pose the question, and hear from students after a pair and share. Then offer a definition of fungi as relevant to student level (i.e. Eukaryotic organisms) and show some pictures of fungi. Students work together to draw a map of the area around the school. They predict where fungi might be on the map, and explain their thinking and the assumptions they are making. They take a walk around the school, look on the ground, in ponds or puddles, tree stumps, soil, and other areas. They try to spot evidence of fungi. If any fungi is found, they mark it on their map with a quick sketch, picture or description. They bring their maps back to the classroom and compare notes. (If appropriate, students could bring samples back to the classroom) Explain to students that the parts of fungi that we see are generally just the spore producing fruiting body. They are mostly composed of threadlike hyphae that explore through growth; and that they live inside their food, digesting it while it surrounds their hyphae and then absorbing it. This means that there is far more fungi than they were able to find! Also mention that many fungi are so small that they are invisible. Discuss with students whether they had any assumptions about fungi that they need to reappraise (e.g. that fungi are always visible). Introduce students to the Driving Question (DQ) Board (this is an area accessible to all students where the driving question (the unit title) is written and students can place and arrange related questions, comments, or ideas). They work in groups to develop three or four questions about fungi. Encourage students to ask about unusual, imaginative, or novel topics related not just to the biology and classification of fungi but also their role and uses. Students categorise the questions together, and write in their notebooks initial responses to one or more of the questions posed by other groups. Share out thoughts.	Fungi, eukaryotic organisms, spores, hyphae Sharing background knowledge of fungi.	Inquiring: Observe, describe relevant experiences about fungi. Imagining: Generate unusual and novel questions about fungi.	Inquiring: Identify and question assumptions about the nature of fungi, become aware of gaps in knowledge.

2	Lesson period 3	Lead an exploratory discussion about optimal conditions for fungi. Have students describe where they have seen fungi, where (under what conditions) they think it grows best and some of the basic features of fungi (students may also be asked to read given texts or online to support this). In small groups, using the information they have gathered, students plan an investigation where they will explore optimal conditions for growing fungi by attempting to grow fungi in different conditions. The teacher can help the students add to their ideas of different conditions (would fungi grow best on buried materials? Underwater? Wet, dry? On food or wood or rock? How about in an old shoe? Under pressure? etc.) What assumptions are you making in coming up with these ideas for conditions? Students should come up with and discuss several possible proposals (including one they think is novel or unusual) before choosing one. Ask students to consider and share the strengths and limitations of the plans that they come up with, including how novel and unusual they are and explain what criteria they use to select their final plan. Students add questions to the DQ Board. Review the questions to see if any have been answered and if any more can be answered.	Fungal growth requirements and environmental conditions. Gathering information, planning an investigation.	Doing: Propose how to investigate a scientific problem about growing fungi and the ideal environment for growth in a personally novel way.	Doing: Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria. Students give feedback about each other's approaches and suggest improvements.
3	Lesson period 4 and 5	Students are provided with old fruit, vegetables, bread, plastic bags, water, and spray bottles (and other materials in their plans). They set up the investigation they planned in step 2 to test the predictions that they made about a suitable environment for fungi. Students, in small groups, write out the prediction about in what conditions they think fungi might grow, based on the investigations they planned in step 2, and how they are testing and collecting data based on the prediction. Students may want to add moisture, increase or decrease the temperature or change other factors. The teacher leads a group discussion about what has been predicted and how and why the students arrived at their predictions (what assumptions did they involve). If there is one group that is needing more support, the teacher could work with this group and the whole-class as a model for the other students of expectations and possibilities. (Optional: Start the mushroom growing kit.) Students add questions to the DQ Board.	The effect of added moisture, increases in temperature or other factors on fungi growth	Doing: Implement a personally novel investigation of the best conditions for growing fungi.	

4	Lesson period 6 and 7	Class reads a short text about the omni-presence of fungi in the environment, the way that fungi function in symbiosis with plants, and how they sequester carbon. The reading could be done in a whole group, in partners or independently. **Before** reading the text, the whole class can look over the text to identify words that they may need support in understanding so the class can work on definitions together. The class also discusses what sequester means and the importance of sequestering carbon to slow climate change, with the teacher stepping in to explain as needed. For example, the teacher may say that carbon sequestration is the process of capturing and storing atmospheric carbon dioxide (CO2) so there is less in the atmosphere. This may also be a good time to explain that trees are made of carbon from when C02 is split by the energy of the sun into carbon and oxygen and so play a role in carbon sequestration. Ask a few students to create models or dramatisations of sequestering carbon dioxide. Teacher then works with the students to come up with ideas about how the environment can be changed to be more or less hospitable to fungi, and think about what would facilitate or block these changes and whether different people would have different perspectives on those changes. They then draw on these ideas to create a dramatisation or model of the process that shows these different perspectives. Ask students to return to their predictions about what conditions help fungi grow, and consider those predictions based on the new information. Some students revise their predictions. Students add questions to the DQ Board.	Fungi functions. Carbon sequestration. Students connect their knowledge of carbon dioxide and plants and the interactions with the environment as a whole with what they already know and have learned in this lesson about fungi.	Imagining: Generate and play with unusual and radical ideas about how to model or dramatise sequestering carbon dioxide and for modifications to the environment. .	Imagining: Considering several perspectives regarding environmental changes that are more or less hospitable to fungi
5	Lesson periods 8 and 9	Using the entire class's investigations, as well as any fungi gathered from the outside investigation, students make observations. They use microscopes or magnifying glasses to observe the fungi. They work on the question of what fungi does to organic material. The teacher should point out changes to the material, such as its texture, its colour, and smell. The teacher hands out science notebooks or paper so the students can draw models of the specimen. They can be asked to draw two different models that emphasise different things about fungi. These can be shared with all of the class through a walking museum, partner share, or online, such as a slideshow.	Using microscopes and microscopic features of fungi What fungi does to organic material Drawing specimens.	Doing: Creating models of fungi in a personally novel manner.	Reflecting: Reflect on the chosen scientific solution and consider possible alternatives about how fungi grows, what it consumes when it grows and what changes manifest both to the organic

		Have students share what they are noticing about fungi with each other and decide if their predictions about what conditions would work best for fungi were accurate and revise their models.. Students add questions to the DQ Board and check to see if any questions have been addressed.	Students check on the progress of their investigations, produce models, and compare results.		material and to the fungi.
6	Lesson period 10,11 (this could extend into the 12th lesson plan)	In small groups, students create a 'fungi owners' manual' relating what they learned about what environments and conditions are important for fungi. They are encouraged to think of some unusual or imaginative ways that they could make their manual more informative, useful, and memorable for future fungi owners. They share their manuals with the class. They consider whether it is likely that their results hold true for all fungi or are likely to be only true for the specific fungi that are in the chosen materials and discuss remaining uncertainties. They discuss, draw and label the features of fungi (including features that are too small to see) Students address all questions on the DQ Board.	Features of fungi fungi growing conditions.	Doing: Produce a meaningful and personally novel fungi owners' manual. Reflecting: Reflect on steps taken to pose and solve a scientific problem	Reflecting: Evaluating and acknowledging uncertainty or limits of endorsed position.
7	Lesson period 12	Support students (by providing resources, making suggestions, asking questions, and giving feedback) in creating a rubric for success and evaluate whether they have met their criteria (creating the rubric could also take place before students start work on their solution). As relevant to the local context, the teacher could suggest that the rubric covers creativity and critical thinking, perhaps drawing on the OECD creativity and critical thinking rubrics. If they have not met the criteria, they redesign their solution so it can meet the criteria. They share their manuals with others in the school, a local community centre, or grocery store.	Reflecting and consolidating knowledge gained during the unit.	Reflecting: creating rubrics to support reflection on the relevance and novelty of their manual.	Doing: Evaluating the strengths and limitations of their work, using self-generated criteria.

Resources and examples for inspiration

Web and print

- Fungi and climate (resource for the teacher)
- structure of fungi Another structure diagram
- L 3 Information for students to browse (attributions: Wiki)
- L4 Video on fungi (youtube) Watch 3:22- 8:01

Other

- L3 materials for growing moulds: old fruit, bread, paper and plastic bags, other items suggested by the class. Mushroom growing kit (example here)
- L6 and 7 microscopes or magnifying glasses for small groups

Creativity and critical thinking rubric for science

Mapping of the different steps of the lesson plan against the OECD rubric to identify the creative and/or critical thinking skills the different parts of the lesson aim to develop

	CREATIVITY Coming up with new ideas and solutions	Steps	CRITICAL THINKING Questioning and evaluating ideas and solutions	Steps
INQUIRING	Make connections to other scientific concepts or conceptual ideas in other disciplines	1	Identify and question assumptions and generally accepted ideas of a scientific explanation or approach to a problem	1
IMAGINING	Generate and play with unusual and radical ideas when approaching or solving a scientific problem	4	Consider several perspectives on a scientific problem	4
DOING	Pose and propose how to solve a scientific problem in a personally novel way	2,3,5,6	Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria (practical, ethical, etc.)	2
REFLECTING	Reflect on steps taken to pose and solve a scientific problem	7	Reflect on the chosen scientific approach or solution relative to possible alternatives	5,6