Working safely with micro-organisms in Laboratory Science: Practical Skills (National 5)

Laboratory Science: Practical Skills **(National 5) is a mandatory unit within the *National 5 Laboratory Science Skills for Work Course* [1]. Outcome 1 of the unit requires learners to demonstrate competence in some basic laboratory microbiological techniques, namely pouring media plates, subculturing of micro-organisms, preparing slides for microscopy and an awareness of appropriate safe disposal of microbiological waste. This involves learners in developing aseptic technique together with an awareness of the health and safety aspects of working with micro-organisms.**

At SSERC we believe in the considerable educational value of carrying out school practical work involving micro-organisms which, as the Safety in Microbiology Code of Practice says,

> *'... lends itself to investigative work in science and to the discipline of developing competence in practical skills. Microbiological skills are key components in the field of biotechnology and in the medical industries and services. The applications of microbiology are relevant to the everyday concerns of citizens in relation to food production, hygiene, health and waste management. It also allows for the evaluation and control of risk, a valuable life skill, as well as providing an insight into an area of science in which Scotland is a major global contributor in research and industrial production. In the 21st century responsible citizens will need to evaluate scientific issues related to microbiology and to develop informed views on the use and applications of micro-organisms.' [2]*

We are pleased that there is a growing interest amongst school science departments in offering the *National 5 Laboratory Science Skills for Work Course* to young people interested in developing their practical laboratory skills. Of course, microbiology is not the only practical component of the course; learners measure radioactivity, use various types of laboratory instruments and perform titrations [1]. However, the interdisciplinary nature of the course is generating questions to SSERC from interested science departments about the training requirements for both teaching and technical support staff, especially the requirements for the microbiology component.

Laboratory Science: Practical Skills **(National 5)**

Outcome 1 - Performance evidence [1]

Learners will work safely with micro-organisms in a laboratory setting
Learners will be required to demonstrate by practical activity that they are able to:

- Pour agar plates using aseptic technique to a satisfactory standard
- Subculture micro-organisms (bacteria, yeast **and** mould) using aseptic technique without contamination. Learners must subculture **each** micro-organism type using **one** of the following subculture techniques:
  - Liquid to solid
  - Liquid to liquid
  - Solid to liquid
  - Solid to solid
- Prepare wet and dry mounts to satisfactory standard. The preparation is in accordance with given instructions and the mounted material is clearly visible when viewed using a microscope.
- Work safely throughout.

Figure 1

This article aims to address the issues of training requirements and the levels of work appropriate to learners and their teachers working safely with micro-organisms to achieve the *Laboratory Science: Practical Skills* (National 5) outcomes and performance criteria (see Figure 1).

Risk assessment and the Code of Practice

Activities involving micro-organisms are controlled by the Control of Substances Hazardous to Health (COSHH) Regulations and teachers and technicians have a duty under the Health and Safety at Work Act to comply with any safety instructions given by their employers. These include using model risk assessments. In Scotland all 32 local authorities and SSERC member schools and >>

colleges have adopted the Code of Practice - *Safety in Microbiology for Scottish Schools and Colleges*, SSERC, 2018 [2] and Figure 2.

The process of risk assessing work involving microbiology should be to identify the risks in any activity and to consider adopting the Code of Practice as being suitable and sufficient to control these risks. By following the Code of Practice in this way, a risk assessment is being carried out. If an activity falls outwith the guidance in the Code of Practice, then an individual risk assessment for that activity must be carried out. **If an employer has provided additional guidance on assessing and recording risk, that guidance must be followed.**

Teacher/technician training and levels of work

Central to the Code of Practice is the concept of levels of work. Three levels of work are determined by a combination of risk factors including choice of micro-organism, teacher training, age of learners and availability of trained technicians [2]. For level 1 work with learners (primary or early secondary), teachers do not require specialist microbiological training beyond normal good school science laboratory practice. For level 2 work with learners (early secondary to senior phase), science teachers may require training and some supervision which can be provided by a knowledgeable teacher (most often a biologist) or technician or by a short in-school training session. The SSERC instruction sheets and short films Microbiological Techniques [3] should be a useful resource in such training as will reference to and familiarity with the Code of Practice [2]. Most school microbiological laboratory work carried out by learners will be at levels 1 and 2, although students in the senior phase may carry out particular level 3 tasks under the supervision of a teacher, or technician trained to level 3.

In order to support level 2 microbiological laboratory work in schools and to supervise students who carry out level 3 tasks, staff trained to level 3 are required. For level 3 work teachers and technicians should be thoroughly trained and skilled in aseptic technique (see Figure 3).

See also a more detailed SSERC statement on training requirements [4].

Level 3 tasks required to support microbiological work in schools:

a) order, receipt, labelling and storage of cultures;
b) preparation of sterile media and sterile equipment;
c) preparing sub cultures for class use;
d) sampling from bioreactors;
e) sterilisation and disposal of cultures;
f) sterilisation of used equipment;
g) management of incidents of spillage;
h) staining of incubated plates (e.g. starch agar).

Figure 3

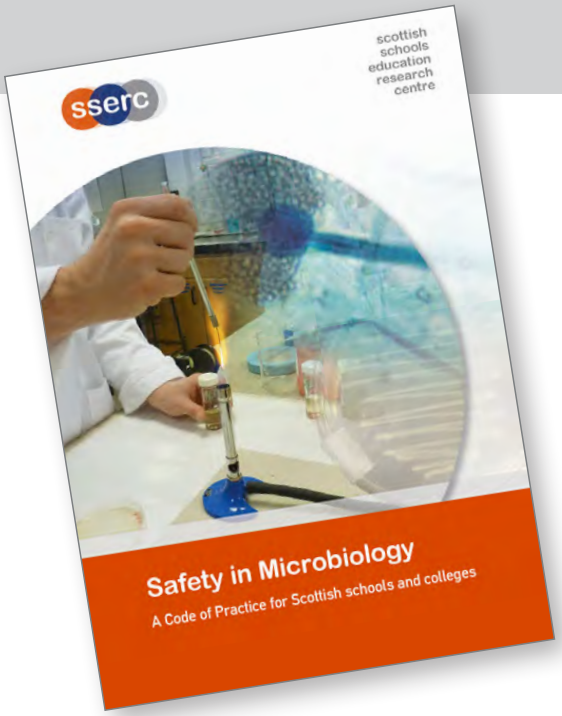

Figure 2 - *Safety in Microbiology - A Code of Practice for Scottish Schools and Colleges* [2].

How do these levels apply to *Laboratory Science: Practical Skills* (National 5)?

It is possible to meet the Outcome 1 performance criteria by carrying out only work at level 2. Done in this way, no specialist training is required for teachers beyond an in-school training session delivered by someone themselves trained to level 3. In order to carry out tasks to support the delivery of the course the expertise of someone (usually a technician) trained to level 3 is required (see Figure 3).

Subculture work can be carried out by learners using known micro-organisms deemed to be safe for use in schools. These are listed in appendices 1, 2, 3 and 4 of the Code of Practice [2] and should be sourced from recognised suppliers. However, confining work to level 2 for teachers and learners requires cognisance of some subtleties in the Code of Practice. The issue is the techniques which require transfer of an organism from a liquid culture. Transfer from liquid cultures increases the risk of spillage, or the formation of aerosols (invisible 'mists' of small droplets of moisture which might contain microbes that could be inhaled). Done using Appendix 2 organisms (Figure 4), these liquid transfers are level 3 tasks and would, therefore, require learners to be trained and supervised by someone trained to level 3. The easiest way to minimise risk and restrict liquid transfers to level 2 work is to use *Saccharomyces cerevisiae* (yeast) which is listed in Appendix 1 (Figure 5). By using *Saccharomyces cerevisiae* (yeast) for liquid to solid, and liquid to liquid transfers the learning outcomes for *Laboratory Science: Practical Skills* (National 5) can be met by learners and teachers working at level 2.

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APPENDIX 2

Selected organisms for work at levels 2 and 3

All micro-organisms listed in Appendix 1 and the following organisms:

Fungi
Agaricus bisporus
Armillaria mellea
Aspergillus oryzae
Botrytis cinerea
Botrytis fabae
Chaetomium globosum
Coprinus lagopus
Fusarium graminearum
Fusarium solani
Fusarium oxysporum
Helminthosporium avenae
Kluveromyces lactis
Lindnera jadinii (also called *Candida utilis*)
Monilinia fructigenea (also called *Sclerotinia fructigena*)
Mucor hiemalis
Mucor mucedo
Myrothecium verrucaria
Neurospora crassa
Penicillium expansum
Penicillium roquefortii
Phaffia rhodozyma (e.g. coloured organism)
Physalospora obtusata
Phycomyces blakesleanus
Phytophthora infestans
Plasmodiophora brassicae
Pleurotus ostearus
Pythium de baryanum
Rhizopus oligosporus
Rhizopus sexualis
Rhizopus stolonifer
Rhytisma acerinum
Saccharomyces cerevisiae
Saccharomyces diastaticus
Saccharomyces ellipsoides
Saprolegnia litoralis
Schizosaccharomyces pombe
Sordaria fimicola
Sporobolomyces species
Trichoderma reesei

Bacteria
Acetobacter aceti
Agrobacterium tumefaciens
Azotobacter species
Alcaligenes eutrophus
Bacillus megaterium
Bacillus stearothermophilus
Bacillus subtilis
Cellulomonas species
Chromatium species
Janthinobacterium lividum (also called *Chromobacterium lividum*)
Escherichia coli (strain B or strain K12)
Gluconobacter oxydans
Lactobacillus species
Micrococcus luteus (also called *Sarcina lutea*)
Micrococcus roseus
Methylophilus methylotrophus
Pectobacterium carotovorum (also called *Erwinia carotovora*)
Photobacterium phosphoreum
Pseudomonas fluorescens
Rhizobium species
Rhodopseudomonas palustris
Spirillum serpens
Staphylococcus epidermidis
Streptococcus lactis
Streptococcus thermophilus
Vibrio natriegens (also called *Beneckea natriegens*)

Viruses
Cucumber Mosaic Virus
Potato Virus X
Potato Virus Y (not the virulent strain)
Tobacco Mosaic Virus
Turnip Mosaic Virus

Figure 4 - *Safety in Microbiology - A Code of Practice* Appendix 2.

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APPENDIX 1

Selected organisms for work at level 1

- Bread making or brewer's yeast (*Saccharomyces cerevisiae*)
- Dried yoghurt cultures (bacteria used to make yoghurt)
- Blue-green algae
- Green algae
- Free living protozoa
- Lichens
- Slime moulds

Figure 5 - *Safety in Microbiology - A Code of Practice* Appendix 1.

Our recommendations for organisms to be used to carry out the required microbiological techniques for *Laboratory Science: Practical Skills* (National 5) course while working at level 2 are shown in Figure 6.

These recommendations make it possible to perform the appropriate techniques using the required range of organisms for *Laboratory Science: Practical Skills* (National 5) without level 3 training for teachers or learners. It is worth re-emphasising that it is still necessary to have someone within the school trained to Level 3 in order to carry out the relevant technical support tasks described in Figure 3.

It should be noted that SSERC has recently revised *Safety in Microbiology - A Code of Practice for Scottish Schools and Colleges*. All references in this article are to the revised version which is available on our website [2]. <<

Technique	Organism	Code of Practice reference	Type
Solid to solid	*E. coli* or *M. luteus* or *B. subtilis*	Appendix 2	Bacterium
Liquid to solid	*S. cerevisiae* (yeast)	Appendix 1	Fungus
Solid to liquid	*E. coli* or *M. luteus* or *B. subtilis*	Appendix 2	Bacterium
Liquid to liquid	*S. cerevisiae* (yeast)	Appendix 1	Fungus
Solid to solid	*Mucor hiemalis*	Appendix 2	Mould

Figure 6

References

[1] *Laboratory Science: Practical Skills* (National 5) Skills for Work Unit Specification June 2017 link to SQA website https://www.sqa.org.uk/sqa/38267.html.

[2] *Safety in Microbiology - A Code of Practice for Scottish Schools and Colleges*, SSERC, 2018 available at https://www.sserc.org.uk/health-safety/biology-health-safety/codes-of-practice/.

[3] SSERC Microbiological techniques. Available at https://www.sserc.org.uk/health-safety/biology-health-safety/microbiological-techniques/.

[4] Advice on Training Requirements. Available at https://www.sserc.org.uk/health-safety/biology-health-safety/updates-on-health-and-safety-practice/.

Further reading and useful websites

- SSERC Microbiological techniques. This is a series of both cards and films which will be a useful source of training for teachers and learners, available at https://www.sserc.org.uk/health-safety/biology-health-safety/microbiological-techniques/.
- Topics in Safety, Topic 15: Microbiology, Association for Science Education, 2018.
- Basic Practical Microbiology: A Manual, Microbiology Society, 2016.
- Microbiology Online. This is the education resource website of the Microbiology Society, available at https://microbiologyonline.org/.