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4 1 **Short running head:** Historic uses of fungi for textile

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7 2 **Title:** Fungal mycelial mats used as textile by Indigenous People of North America

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27 9 **ABSTRACT**

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30 10 The indigenous people of the United States and Canada long have used forest fungi for food, tinder,

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32 11 medicine, paint, and many other cultural uses. New information about historic uses of fungi continues to

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34 12 be discovered from museums as accessions of fungi and objects made from fungi collected over the last

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36 13 150+ years are examined and identified. Two textiles thought to be made from fungal mats are located

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38 14 in the Hood Museum of Art, Dartmouth College and the Oakland Museum of California. Scanning

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40 15 electron microscopy and DNA sequencing was used to attempt to identify the fungus that produced the

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42 16 mats. Although DNA sequencing failed to yield a taxonomic identification, microscopy and

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44 17 characteristics of the mycelial mats suggest that the mats were produced by *Laricifomes officinalis*. This

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46 18 first report of fungal mats used for textile by indigenous people of North America will help to alert

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48 19 museum curators and conservators as well as mycological researchers to their existence and hopefully

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50 20 lead to more items being discovered that have been made from fungal fabric.

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52 21 **KEYWORDS:** Agarikon, biofabrication, ethnomycology, *Fomitopsis officinalis*, *Laricifomes officinalis*,

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54 22 mycotextile

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7 24 **INTRODUCTION**

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10 25 Recently new bioprocessing technologies have grown mycelial cultures of different Basidiomycota and
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12 26 engineered durable mushroom-based fabric for clothing and textile material. One application for these
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15 27 mycofabrics is to replace real and synthetic leather (Bayer and McIntyre 2016; Araldi et al. 2017; Haneef
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17 28 et al. 2017; McIntyre et al. 2018). The idea of using mycelial mats for textiles, however, was known by
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19 29 the indigenous people of North America for some time as evidenced by the two textiles studied in the
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22 30 paper reported here. These fungal textiles were made over 100 years ago. Finding examples of these
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24 31 objects, however, has been difficult since many cultural properties made of fungi have been listed as
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26 32 made from unknown material or misidentified as wood or other plant materials. One well known type of
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28 33 fabric made from the processed mycelium of *Fomes fomentarius* fruiting bodies has been used in
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30 34 Eastern European countries to make hats and other items that utilize a thick felt-like material (Pegler
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32 35 2001).

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40 37 A fungal textile used by the indigenous people of the Pacific Northwest Coast of North America was a
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42 38 Tlingit wall pocket from Ketchikan, Alaska made in 1903. This has been in the Hood Museum of Art
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44 39 storage at Dartmouth College for over 60 years with the note “Pair of Fungus Bags. Wedding Presents
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46 40 from Indian Neighbors at Ketchikan, 1903” (Figure 1). When the item was gifted to the Hood Museum in
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48 41 1959, accession information indicated that the pair had been separated with one given to the Hood
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50 42 Museum and the other given to the Oakland Museum of California. Oakland ‘s accession information
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52 43 included a note: “Wall pouch made of cedar fungus”. Both of these objects were not made of animal
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54 44 hide or fur used for souvenirs; or cloth, typically used for personal items or gifts (Smetzer 2014). This
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4 45 paper reports the results from an examination of these historic wall pockets and demonstrates they
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6 46 were made from mycelial felts that provided a durable long-lasting fabric.

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10 48 **MATERIALS AND METHODS**

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16 49 The wall pockets were faced with a cream colored, supple, striated material that appeared to be, as the
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18 50 museum notes suggest, some sort of fungal material. The wall pockets, a Victorian form, are ornamental
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20 51 objects used to hang on the wall with a pouch or pocket to hold household items. The two are not a
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22 52 matched pair. The unrecorded Tlingit maker created two different shaped wall pockets but each
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24 53 adorned with a variation of traditional foliate / seaweed / kelp beadwork designs. The fungal material
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26 54 facing, glass seed beads, black cotton trim, calico cloth lining and flannel backing are identical (Figure 1).
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28 55 Oakland's wall pocket is 22 x 13 cm and the Hood's is 17.7 x 12.7 cm. Small segments of the material
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30 56 were removed by Christine Puza, conservator, Williamstown Art Conservation Center, Williamstown, MA
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32 57 from the inside seams of the Hood Museum's wall pocket. These detached segments were used for DNA
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34 58 testing and scanning electron microscopy. Some segments were mounted directly onto stubs for
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36 59 observations without fixation and were mounted on aluminum stubs and coated with gold/palladium
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38 60 using a Cressington 108 auto sputter coater (Cressington Scientific Instruments, Watford, United
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40 61 Kingdom) and examined with a Hitachi S3500N scanning electron microscope (Hitachi, Tokyo, Japan).
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50 63 Additional segments were used for DNA extraction. Samples of the mycelial textile were extracted using
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52 64 previously published protocols (Loyd et al. 2018) and PCR protocols following Blanchette et al. (2016). In
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54 65 addition to PCR testing of genetic markers, a "shotgun sequencing" methodology was explored in the
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56 66 event the DNA was too fragmented to be PCR-amplified. These experiments were conducted in a
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58 67 dedicated ancient DNA facility using methods proven to be effective for degraded DNA from
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4 68 archaeobotanical remains (Wales et al. 2014). The only modification to the protocol was that the
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6 69 specimen, a 1 mg segment of the wall pocket, was incubated in digestion buffer for 10 minutes to
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9 70 reduce contaminant DNA (known as a “pre-digestion” step). Subsequently the specimen and the pre-
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11 71 digestion buffer were separately processed, along with a water control to monitor for potential
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14 72 contamination. All three DNA extracts were converted to Illumina libraries for high-throughput
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16 73 sequencing following a method optimized for DNA recovery (Carøe et al. 2017). The libraries were
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18 74 amplified with sample-specific barcodes using 20 cycles in PCR and then pooled for sequencing on a
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21 75 portion of a lane of an illumine HiSeq4000 platform in 80bp single read mode. The resulting DNA data
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23 76 was explored in three ways: comparing against the NCBI nucleotide data base using BLAST (Altschuet et
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25 77 al 1990) and MEGAN6 (Hudson et al. 2011), comparing to a curated database of fungal genomes using
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28 78 MALT (Herbig et al. 2017), and mapping to Fomitopsisaceae reference genomes using BWA (Li and
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30 79 Durbin 2009) as implemented in the Paleomix bioinformatics pipeline (Schubert et al. 2014).
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37 38 39 82 **RESULTS AND DISCUSSION**

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42 83 Scanning electron microscopy revealed that the textile used was made from fungal mycelium that
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44 84 formed a dense mat. Some minute wood segments adhered to the surface of the fungal mat suggesting
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47 85 this was extracted from the cracks that are formed in brown rotted wood by some Basidiomycota.
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50 86 Fungal filaments from some parts of the textile showed smooth hyphal surfaces while others have a
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52 87 rough surface with granular particles (Figure 3). The mycelium also had characteristics of hyphae
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54 88 produced by *Laricifomes officinalis* (syn. *Fomitopsis officinalis*, *Fomes laricis*). This includes mycelial mats
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57 89 with uniform tightly woven hyphae that branch at infrequent intervals at right angles as reported by
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59 90 Faull (1916). These characteristics were observed in the samples of wall pockets we examined (Figure 3).
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4 91 In culture, *L. officinalis* produces chlamydospores and these structures can be used for differentiating
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6 92 the fungus from most other brown rot fungi. However, microscopic observations of modern mycelial
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8 93 mats show that chlamydospores are rarely present in mats. Scanning electron microscopy observation
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10 94 of a segment of the wall pocket revealed that chlamydospores were infrequent in most of the historic
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12 95 sample sections that were examined but a few intercalary and terminal chlamydospore-like structures
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14 96 were seen (Figure 3). There are other brown rot fungi that produce mycelial mats in decayed wood that
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16 97 can be found in the Pacific Northwest including *Fomitopsis pinicola* (Sw.) P. Karst. sensu lato and
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18 98 *Laetiporus sulphureus* (Bull.) Murrill sensu lato. Some of the species within both of these groups can
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20 99 also produce chlamydospores (Nobles 1965; Haight et al. 2019). The *F. pinicola* group of species grow
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22 100 on downed dead conifers or on dead areas of live trees and *L. conifericola*, the species in the *L.*
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24 101 *sulphureus* complex that occurs in the western United States and Canada on conifers, is restricted to the
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26 102 lower butt region of trees. In advanced stages of decay, cracks within the brown rotted wood can be
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28 103 filled with fungal mycelia. These fungal mats have been referred to as having cobweb characteristics and
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30 104 are thin to thick and usually rather small in size. In contrast, *L. officinalis* can occur throughout the main
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32 105 bole of a tree and is often well established in the tree before the tree fails and falls to the ground. Large
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34 106 areas of the tree may be decayed. As the brown cubicle rot progresses, the fungus fills cracks and voids
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36 107 in the decayed wood with thick mats of mycelium (Faull 1916; Hubert 1931; Gilbertson and Ryvarde
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38 108 1986). *Laetiporus officinalis* is commonly reported to produce mats that are 5 mm thick (Allen et al.
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40 109 1996). With the decay extending through a large part of the tree, the mats can be very large. In old
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42 110 growth trees, they commonly produce especially large sheets of mycelium that can be pulled out from
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44 111 the decayed wood intact in long thick segments. *Laricifomes officinalis* is the only brown rot fungus that
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46 112 has been reported to produce large mycelial mats that are big enough to be suitable for making objects
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48 113 such as the wall pockets (Figure 2). From these macroscopic and microscopic observations and
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4 114 comparisons to previously published information on characteristics of mycelial mats of *L. officinalis*, we
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6 115 conclude that the wall pockets are most likely made from mats produced by *L. officinalis*.

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15 118 To confirm that the mats were produced by *L. officinalis*, segments of the wall pocket were used to
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18 119 extract DNA for sequencing. Unfortunately, there was no success to amplify the ITS region after several
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20 120 attempts. Storage conditions over the past many decades has apparently resulted in poor preservation
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23 121 of fungal DNA in the mycelial mats. The additional shotgun sequence approach for ancient DNA also
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25 122 failed to yield taxonomic identification, although DNA was successfully converted to Illumina libraries
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27 123 and sequenced. The sample, pre-digestion buffer, and blank produced 25.8M, 16.0M, and 210K reads,
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29
30 124 respectively. The BLAST findings, which provide a general perspective on the origins of the DNA,
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32 125 revealed the control was dominated by bacterial species which are known to be common laboratory
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34 126 contaminants (Salter et al. 2014) (Table 1). The specimen and pre-digest demonstrated some of the
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37 127 laboratory contaminants were also present, but neither showed a significant number of reads matching
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39 128 *Laricifomes officinalis* or other members of the order Polyporales (Table 1). A small number of reads
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41 129 matched other fungal taxa such as Pleosporaceae, Hypocreomycetidae, and Malassezia, which were
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44 130 likely contaminating fungi of the wall pocket. MALT analysis of fungal communities showed different
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46 131 fungal families in each sample tested. The control was dominated by Nectriaceae, the predigest was
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49 132 mostly Psathyrellaceae, and the bag specimen was primarily Saccharomycodaceae. These fungi
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51 133 represent taxa that also were contaminating the fungal fabric and reagents used for analyses. The final
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53 134 approach of mapping the sequencing data to Fomitopsidaceae reference genomes found negligible
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55 135 proportions (<0.02% of total reads), likely due to spurious mappings, which again precludes species
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58 136 identification from the DNA data.

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7 138 The growth of some Basidiomycota can produce fungal mats in nature and in culture. One of the most
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9 139 widely known mycotextiles is amadou which is cut out of the top mycelial context of *Fomes fomentarius*
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11 140 fruiting bodies. This layer of mycelium is used in some Eastern European countries to make a thick felt-
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14 141 like fabric for making hats, purses and other items (Pegler 2001). The fibrous mycelial layer has also had
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16 142 a long history of use as tinder for making fires. Thin strips of the dried mycelium extracted from fruiting
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18 143 bodies can easily catch a spark from flint being struck to start a fire. We know from the fungi found
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20 144 associated with the mummified and frozen body of the Tyrolean iceman that this material was used for
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22 145 making fires for over 5000 years (Peintner et al. 1998; Peintner and Pöder 2000). Another fungus used
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24 146 historically in Europe and North America is *Laricifomes officinalis*. This fungus produces felts in the
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26 147 cracks of brown-rotted wood that may be one-quarter inch thick and extend several feet in length in one
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28 148 continuous sheet (Harvey and Hessburg 1992). The largest fungal mats are found in decayed old growth
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30 149 trees and this material was often collected and used as a styptic to stop bleeding. Hubert (1931) reports
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32 150 the indigenous People of Canada and the United States “early learned of its styptic and purgative
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34 151 properties, and under the name of ‘Wabadou’ it was collected and cherished by the medicine men”.
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36 152 Although this fungus is primarily found in the Pacific Northwest, it was reported to grow throughout the
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38 153 white pine range in Ontario and Quebec as well as in Michigan and Wisconsin (New York Botanical
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40 154 Garden accession # 575256, 01966147 and 01966762;;University of Michigan Herbarium #145810; USDA
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42 155 Forest Products Laboratory, Center for Forest Mycology #13208, 12920, 13179) (Neuman 1914). In
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44 156 addition to white pine, it has been found on larch and hemlock in this area. The name ‘Wabadou’ is an
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46 157 Ojibway name with ‘Wab’ meaning white and ‘adou’ a contraction from amadou. Amadou is a French
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48 158 word for the tinder fungus and this name was likely brought to the region by fur traders and French
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50 159 Jesuits (Faull 1919). The cutting of old growth forests during the late 1800’s and early 1900’s appears to
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52 160 have all but eliminated this fungus from the Midwestern United States, Ontario and Quebec and it is
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4 161 now very rarely found in this area. However, it can still be found in western North America. Additional
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6 162 reports of the styptic qualities of *L. officinalis* mycelial mats have also been reported. Gilbertson (1980)
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8 163 indicates that *L. officinalis* “has been thought to have styptic properties and old time lumberjacks
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10 164 reportedly used the extensive mycelial felts in the decayed wood for dressing axe wounds” and
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12 165 McIntyre (1949) notes that *L. officinalis* “mycelial mats or felts had great healing properties for wounds,
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14 166 many veteran loggers collected these felts and stored them for emergency use in the absence of a camp
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16 167 doctor”. Another report that appears to refer to mycelial felts of *L. officinalis* is the use by the Spokan
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18 168 Indians as a diaper material. Ross (2011) describes a “soft pliable growth of vegetative mycelium felt-like
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20 169 membrane referred to as nqa?qe?mín, which can be found beneath the bark of a buckskin tamarack
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22 170 snag, that was carefully peeled off to serve as a cradleboard diaper”. It is possible that this diaper
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24 171 material could have had medicinal use.
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34 173 The note with the Oakland Museum object indicated that the mat was from a cedar fungus. Hosts for *L.*
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36 174 *officinalis* in the Pacific Northwest, however, are pines, fir, larch, Douglas fir, spruce and hemlock.
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38 175 Although western red cedar and *Chamaecyparis* are not hosts, the term ‘cedar’ was likely used in a
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40 176 general way to indicate a conifer. Since there is no mention of cedar with the Hood Museum wall pocket
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42 177 and there appears to be an original note attached to the back of this object, the notes for the Oakland
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44 178 Museum object were apparently made in 1959 without any definitive knowledge of the type of tree the
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46 179 fungus was harvested from.
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54 181 In addition to the use as a fabric reported in this study, *L. officinalis*, commonly known as Agarikon, has a
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56 182 long history of traditional use as a medicine and as objects associated with native spirituality.
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58 183 Dioscorides reports in about 200AD that it can be used to treat many different ailments. Its importance
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4 184 continued to be used over the centuries and was recognized in the early herbals of Europe and into
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6 185 current times (Gilbertson 1980; Stamets 2005; Girometta 2018). In North America, its use in traditional
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8 186 medicine by indigenous people is known from ethnology research and collections and accession notes in
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10 187 natural history museums (Emmons 1902; Faull 1916; Beardsley 1941; Blanchette et al. 1992). Because of
11
12 188 its unusual appearance and effective medicinal uses, *L. officinalis* was thought to have supernatural
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14 189 powers (Blanchette et al. 1992). Carvings of the fruiting bodies were used by shaman all along the Pacific
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16 190 Northwest Coast as part of their ritual paraphernalia. The shaman would routinely use these carvings to
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18 191 provide an added spiritual remedy in addition to its medicinal value to help cure the sick. When the
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20 192 shaman died, these important possessions were placed at the head of their graves. Masks also were
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22 193 carved from the fruiting bodies of *L. officinalis* and used by shaman during important rituals to display
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24 194 supernatural powers (Blanchette 2017). The 'Fungus Dance' was one of these ritual ceremonies that was
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26 195 conducted during an eclipse of the sun or moon (McIlwraith 1948).
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36 197 The use of *L. officinalis* mycelial mats for textile purposes by the Tlingit expands our knowledge of how
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38 198 this fungus was used by Native Americans in the past. Since this fungus was thought to have
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40 199 supernatural and spiritual attributes by indigenous people in the past, the mycelial mats may have also
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42 200 carried some connotations that we do not know about. Additional ethnographic investigations with
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44 201 indigenous elders are warranted to gather more information on past cultural uses of the mycelial mats
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46 202 that were used. Although currently we only know of two objects made from the fungal mats, likely
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48 203 there are more that exist but their identity remains obscure. This report should help in the discovery of
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50 204 more objects made of fungal fabric that may be in museum or other historical collections as
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52 205 conservators, curators and other researchers take a closer look and reexamine objects.
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4 207 DNA technology was not able to provide any information that could be used to confirm the identity of
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6 208 the fungus that produced the mycelial mats. Instead, methods developed by early mycologists to
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8 209 identify Basidiomycota that do not readily produce fruiting bodies in culture were successfully used to
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10 210 differentiate among the few brown rot fungi that can produce mycelial mats in nature. The size and
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12 211 thickness of the mats and the distinctive characteristics of the fungus provide us with information that
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14 212 strongly suggests that these fungal textiles were made from the mycelial mats of *L. officinalis* which was
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16 213 extracted from the cracks of decaying trees with brown rot.
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23 24 215 **ACKNOWLEDGMENTS**

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53
54

55 227 **LITERATURE CITED**

56
57
58 228 **Allen, E, Morrison D, Wallis G. 1996. Common Tree Diseases of British Columbia. Canadian Forestry**
59
60 229 **Service, Victoria British Columbia. 178 p.**
61
62
63
64
65

1 Historic uses of fungi for textile. Blanchette, Haynes and Held
2
3
4 230 Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ. 1990. Basic local alignment search tool. Journal of
5
6 231 Molecular Biology 215(3):403–410.
7
8
9 232 Araldi SJ, Tudryn GJ, Hart CH, Carlton AJ. 2017. Chemically modified mycological materials having
10
11 233 absorbent properties. US Patent 9555395.
12
13
14
15 234 Bayer E, McIntyre GR. 2016. Method for growing mycological materials. US Patent 9,394,512.
16
17
18 235 Beardsley G. 1941. Notes on Cree medicines, based on a collection made by I. Cowie in 1892. Michigan
19
20 236 Academy of Science and Letters 78:483-496.
21
22
23 237 Blanchette RA. 2017 Extraordinary fungal masks used by the Indigenous People of North America and
24
25 238 Asia. FUNGI Magazine 10 (3): 8-12.
26
27
28
29 239 Blanchette R A, Compton BD, Turner NJ, Gilbertson RL. 1992. Nineteenth century shaman grave
30
31 240 guardians are carved *Fomitopsis officinalis* sporophores. Mycologia 84:119-124.
32
33
34 241 Blanchette RA, Held BW, Hellmann L, Millman L, Büntgen U. Arctic driftwood reveals unexpectedly rich
35
36 242 fungal diversity. *Fungal Ecology*. 2016:23:58–65.
37
38
39
40 243 Carøe C, Gopalakrishnan S, Vinner L, Mak SST, Sinding MHS, Samaniego JA, Wales N, Sicheritz-Ponten T.
41
42 244 Gilbert MTP. 2018. Single tube library preparation for degraded DNA. *Methods in Ecology and Evolution*
43
44 245 9:410-419.
45
46
47
48 246 Dschida, WJA. 1998. Fungal cell wall production and utilization as a raw resource for textiles. US patent
49
50 247 5,854,056.
51
52
53 248 Emmons G. 1902. Collection notes for specimens 77870, 78394 and 78731. Notebook of objects
54
55 249 collected by G. Emmons. Field Museum of Natural History, Chicago, Illinois. (Unpublished manuscript).
56
57
58
59
60
61
62
63
64
65

1 Historic uses of fungi for textile. Blanchette, Haynes and Held
2
3
4 250 Faull JH. 1916. *Fomes officinalis* (Vill.), a timber-destroying fungus. Transactions of the Royal Canadian
5
6 251 Institute (Toronto) 11:185-209.
7
8
9 252 Faull JH. 1919. Pineapple fungus or enfant de pin or wabadou. Mycologia 11:267-272.
10
11
12 253 Gilbertson RL. 1980. Wood-rotting fungi of North America. Mycologia 72:1-49.
13
14
15 254 Gilbertson RL, Ryvarde L. 1986. North American Polypores. Vol. 1. Oslo, Norway, Fungiflora. 387 p.
16
17
18 255 Girometta C. 2018. Antimicrobial properties of *Fomitopsis officinalis* in light of its bioactive metabolites:
19
20
21 256 a review. Mycology DOI:10.1080/21501203.2018.1536680.
22
23
24 257 Haight J-E, Nakasone KK, Laursen GA, Redhead SA, Taylor DL, Glaser JA. 2019. Fomitopsis mounceae and
25
26 258 *F. schrenkii* – two new species from North America in the *F. pinicola* complex. Mycologia 111:339-357.
27
28
29 259 Haneef M, Ceseracciu L, Canale C, Bayer IS, Heredia-Guerrero JA, Athanassiou A. 2017. Scientific Reports
30
31 260 7:41292. DOI:10.1038/srep41292.
32
33
34 261 Harvey R D Jr, Hessburg PF Sr. 1992. Long-Range Planning for Developed Sites in the Pacific Northwest:
35
36 262 The Context of Hazard Tree Management. FPM-TP039-92. USDA Forest Service, Washington DC.
37
38
39 263 Herbig A, Maixner F, Bos KI, Zink A, Krause J, Huson DH. 2017. MALT: Fast alignment and analysis of
40
41 264 metagenomic DNA sequence data applied to the Tyrolean Iceman. *bioRxiv*, 050559.
42
43
44 265 Hubert EE. 1931. An Outline of Forest Pathology. John Wiley and Sons. New York. 543 p.
45
46
47 266 Huson DH, Mitra S, Ruscheweyh H-J, Weber N, Schuster SC. 2011. Integrative analysis of environmental
48
49 267 sequences using MEGAN4. Genome Research 21(9):1552–1560.
50
51
52 268 Li H, Durbin R. 2009. Fast and accurate short read alignment with Burrows-Wheeler transform.
53
54
55 269 Bioinformatics 25(14):1754–1760.
56
57
58
59
60
61
62
63
64
65

1 Historic uses of fungi for textile. Blanchette, Haynes and Held
2
3
4 270 Loyd AL, Barnes CW, Held BW, Schink MJ, Smith ME, Smith JA, Blanchette RA. 2018. Elucidating
5
6 271 "lucidum": Distinguishing the diverse laccate *Ganoderma* species of the United States. PLoS ONE 13(7):
7
8
9 272 e0199738. DOI.org/10.1371/journal.pone.0199738
10
11
12 273 McIntyre G, Bayer E, Palazzolo A. 2018. Method for growing mycological biomaterials. US Patent
13
14 274 10,154,627.
15
16
17 275 McIlwraith TF. 1948. The Bella Coola Indians. University of Toronto Press. Toronto, Canada. 1435 p.
18
19
20 276 McIntyre R. 1949. Indian paint and quinine fungus collected. Yosemite Nature Notes 28:4-6.
21
22
23 277 Neuman JJ. 1914. The Polyporaceae of Wisconsin. Bulletin Wisconsin Geological and Natural History
24
25
26 278 Survey 33. Scientific Series No. 10.
27
28
29 279 Nobles MK. 1965. Identification of cultures of wood-inhabiting Hymenomyces. Canadian Journal of
30
31 280 Botany 43:1097-1139.
32
33
34 281 Pegler DN. 2001. Useful fungi of the world: Amadou and Chaga. Mycologist 15:153-154.
35
36
37 282 Peintner U, Pöder R, Pümpel T. 1998 The Iceman's Fungi. Mycological Research 102(10): 1153–1162.
38
39
40 283 Peintner U, Pöder R. 2000. Ethnomycological remarks on the Iceman's fungi. In: Bortenschlager S, Oegg
41
42
43 284 K. eds. The Iceman and his Natural Environment. The Man in the Ice, vol 4. Springer, Vienna.
44
45
46 285 Ross JA. 2011 The Spokane Indians. Published by Michael J. Ross, Spokane, WA.
47
48
49 286 Schubert M, Ermini L, Sarkissian CD, Jónsson H, Ginolhac A, Schaefer R, Martin, MD, Fernandez, R.
50
51 287 Kircher, M. McCue, M, Willerslev E, Orlando L. 2014. Characterization of ancient and modern genomes
52
53 288 by SNP detection and phylogenomic and metagenomic analysis using PALEOMIX. Nature Protocols
54
55
56 289 9(5):1056–1082.
57
58
59
60
61
62
63
64
65

1 Historic uses of fungi for textile. Blanchette, Haynes and Held

2
3
4 290 Smetzer MA. 2014. From bolts to bags: Transforming cloth in 19th century Tlingit Alaska. Journal of
5
6 291 Material Culture 19:59-73.

7
8
9
10 292 Stamets P. 2005. Antipox properties of *Fomitopsis officinalis* (Vill.:Fr.) Bond. Et Singer (Agarikon) from
11
12 293 the Pacific Northwest of North America. Journal of Medicinal Mushrooms. 7:495-506.

13
14
15 294 Wales N, Andersen K, Cappellini E, Ávila-Arcos MC, Gilbert MTP. 2014. Optimization of DNA Recovery
16
17 295 and Amplification from Non-Carbonized Archaeobotanical Remains. PLoS ONE 9(1): e86827.

18
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20 296 <https://doi.org/10.1371/journal.pone.0086827>

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24 25 26 298 **LEGENDS AND FOOTNOTES**

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29 299 **Figure 1.** Tlingit Wall pockets made from mycelial mats. (A) Hood Museum of Art, Dartmouth College

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31 300 Object 159.68.14506 and (B) Oakland Museum of California object H4153.19. Made in 1903 at

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34 301 Ketchikan, Alaska. Wall pockets are works of art used as a receptacle for household items and designed

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36 302 to hang on the wall. A = 27 x 13 cm and B = 17.8 x 12.7 cm. **Provenance:** Made by an unrecorded Tlingit

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38 303 maker, Ketchikan, Alaska; given to Anna Elizabeth Carylton Von Hasslocher (1874- 1964) and Emil

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41 304 Alexander Von Hasslocher (1867-1946), as a wedding present, 1903; given to their daughter, Dorothy

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43 305 Vaughan Haberman (1903-1992); given to the Hood Museum of Art and the Oakland Museum of

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45 306 California, in 1959.

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52 308 **Figure 2.** *Laricifomes officinalis* fungal mats. A. Transverse section of a conifer tree with brown rot (Top

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54 309 photo). Cracks that develop in the brown rotted wood are filled with mycelium that formst thick large

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56 310 mats. B and C. Large mats that were removed from an old growth tree decayed by *L. officinalis*. (Photo C

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59 311 is courtesy of Brenda Callan, Pacific Forestry Centre, Victoria BC Canada).

1 Historic uses of fungi for textile. Blanchette, Haynes and Held

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7 313 **Figure 3.** Scanning electron micrographs of fungal textile from the Hood Museum of Art wall pocket. A.

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9 314 Micromorphological observations show the textile consisted of a dense mat of fungal mycelium. B to D.

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11 315 Hyphae characteristics of the mycelial textile included hyphae that branched at right angles (arrows in

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13 316 B), and infrequent intercalary and terminal chlamydospores (arrows in C and D). These are

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15 317 characteristics of *Laricifomes officinalis*. Bar = 50 µm in A and 5 µm in B, C and D.

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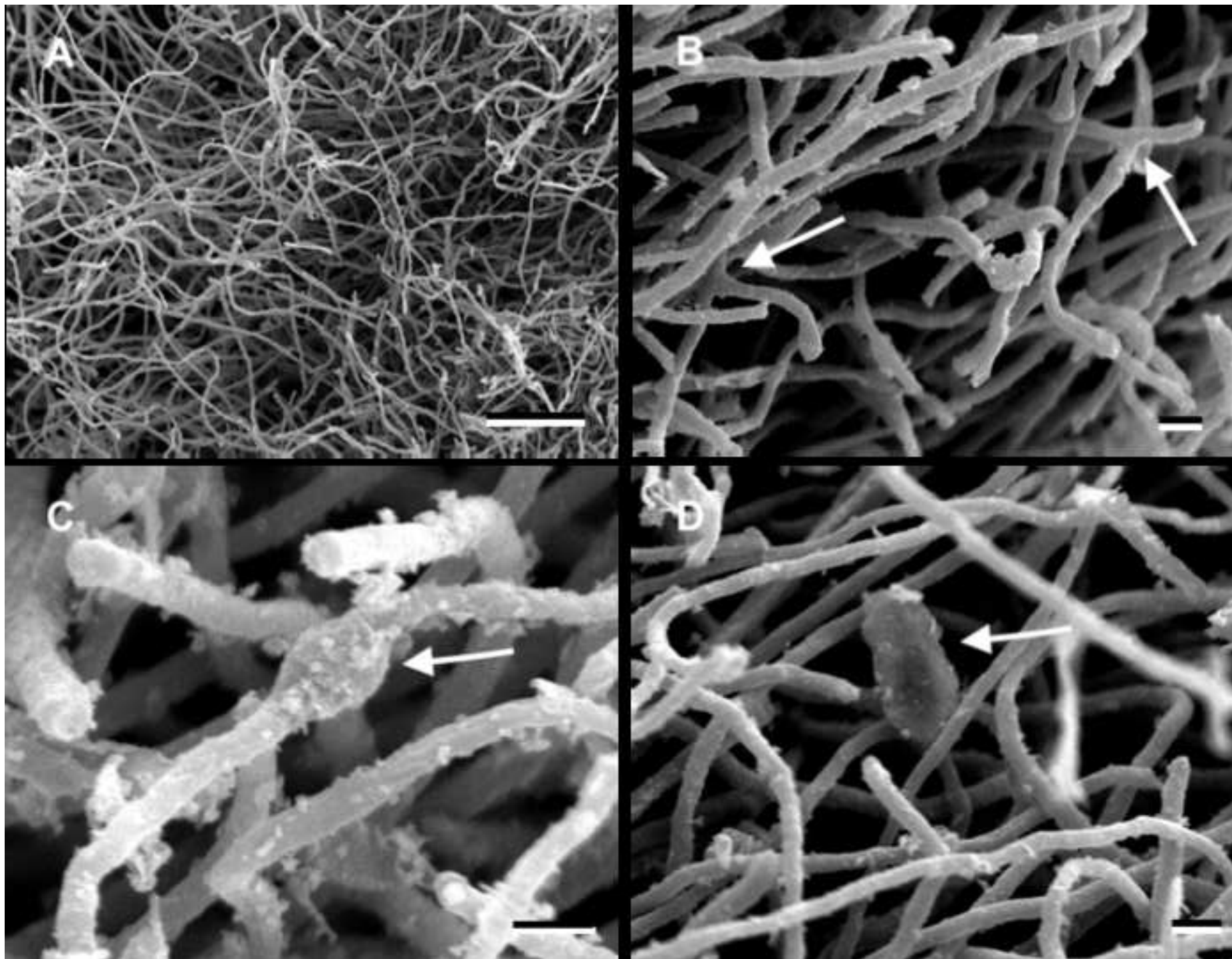


Table 1. Taxa identified in BLAST analysis. 100,000 reads were compared to the NCBI nt database to infer the origins of the DNA in each Illumina library. Very few DNA molecules from the wall pocket specimen are assigned to Polyporales, which prevented a robust taxonomic assignment using this approach.

Taxa	Wall pocket specimen	Pre-digest	Extraction control
Polyporales	0.07%	0.07%	0.00%
Other fungi	0.25%	0.24%	0.11%
Plant	2.17%	0.25%	2.16%
Alphaproteobacteria	2.80%	2.30%	2.11%
Betaproteobacteria	14.89%	10.48%	23.92%
Gammaproteobacteria	2.98%	2.58%	4.09%
Terrabacteria	5.32%	6.45%	1.59%
Higher taxonomic levels	3.02%	3.17%	4.09%
Not assigned	46.30%	45.68%	58.30%