The Stories that Place Tells

8th Annual
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Sydney, NS, Canada

Sana Kavanagh,
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Cheryl Bartlett

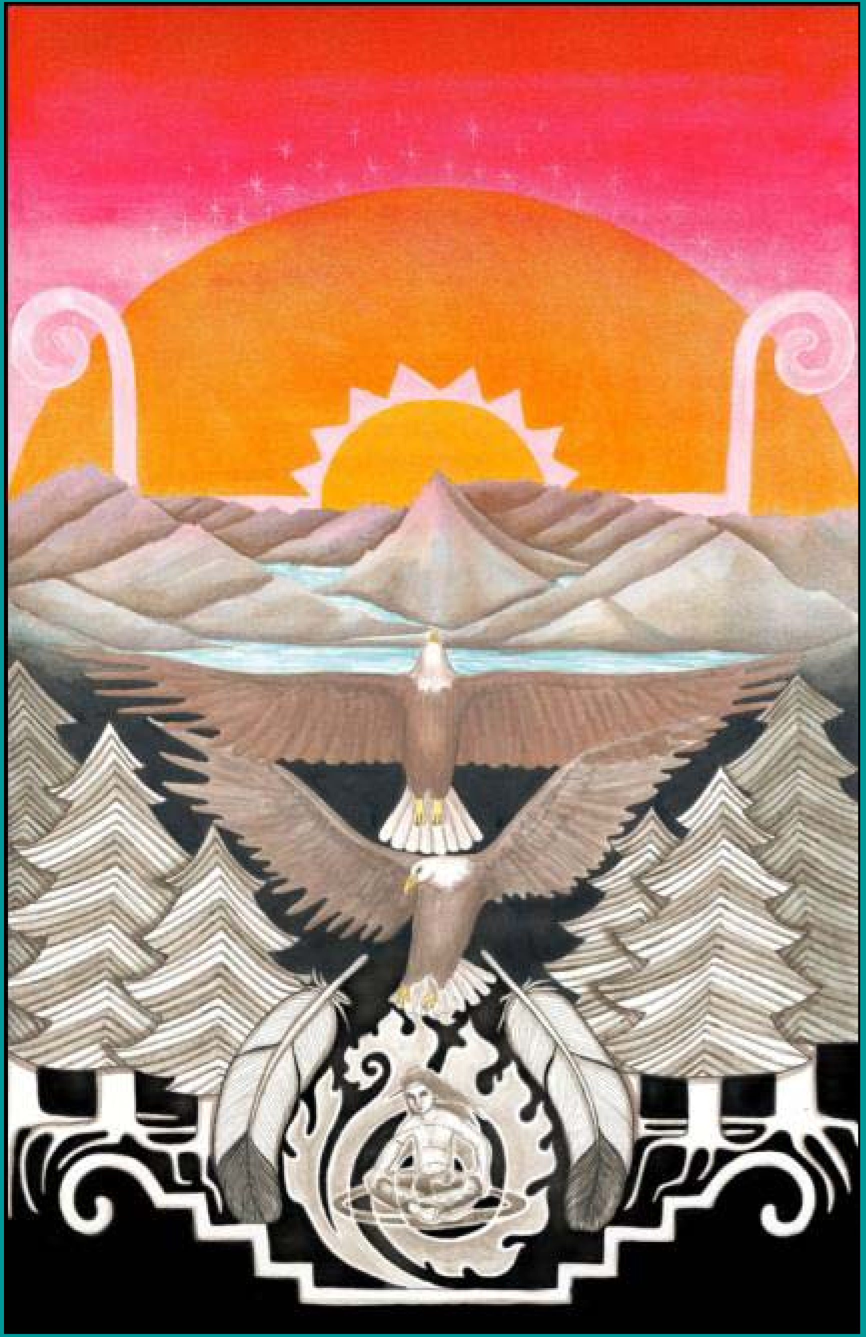
What is … ?

Integrative Science

university science

UCCB
University College of Cape Breton

4 year degree program



What is "Integrative Science"?

"bringing knowledges together"
Aboriginal – Western scientific


The
Stories
that
Place ?
Tells

45°48’ - 47°13'

59°42' - 61°57'

Location

Native Council of Nova Scotia
Mi'kmaq Language Program
Artist: Michael J. Martin

Native Council of Nova Scotia
Mi'kmaq Language Program
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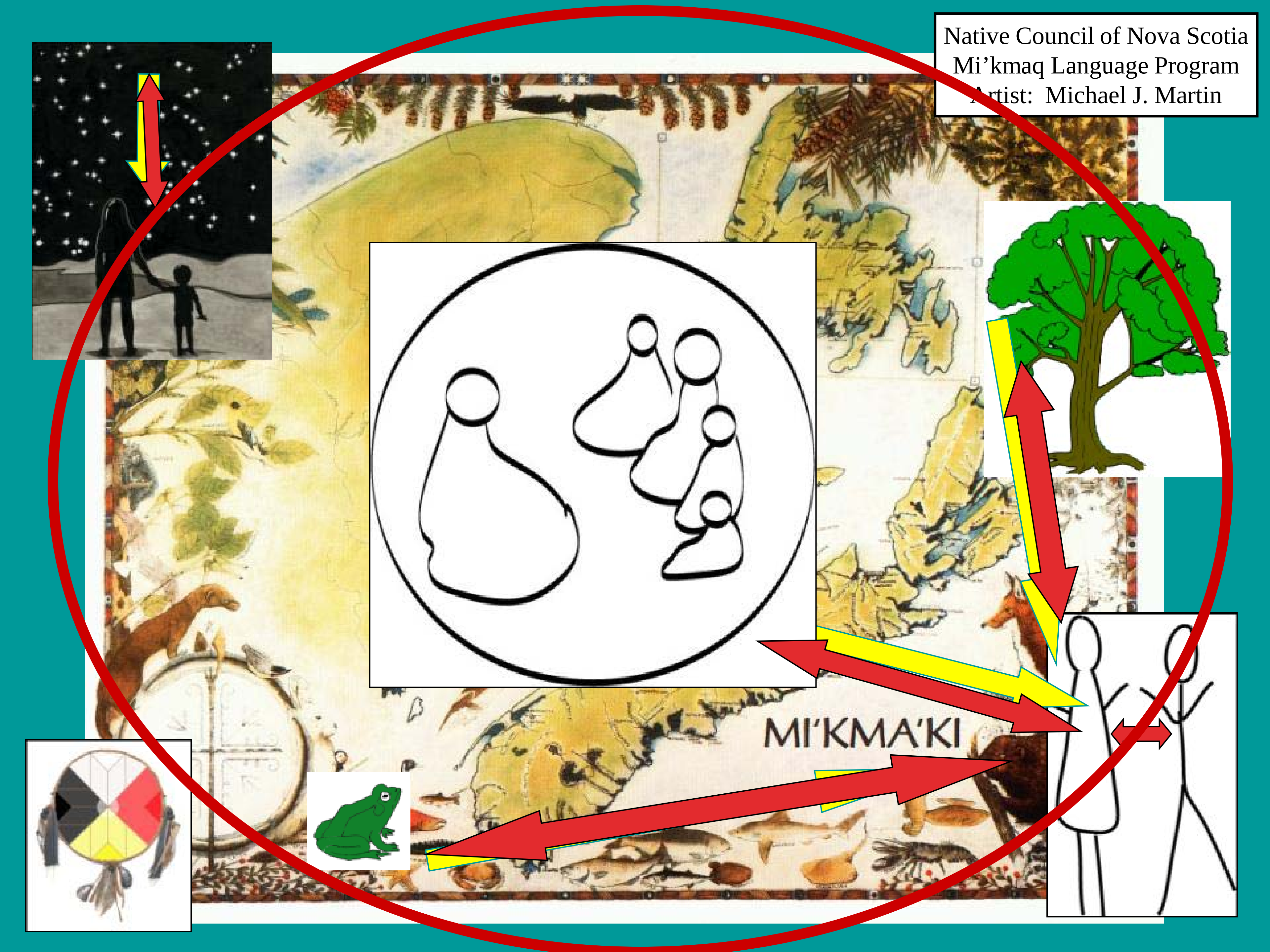
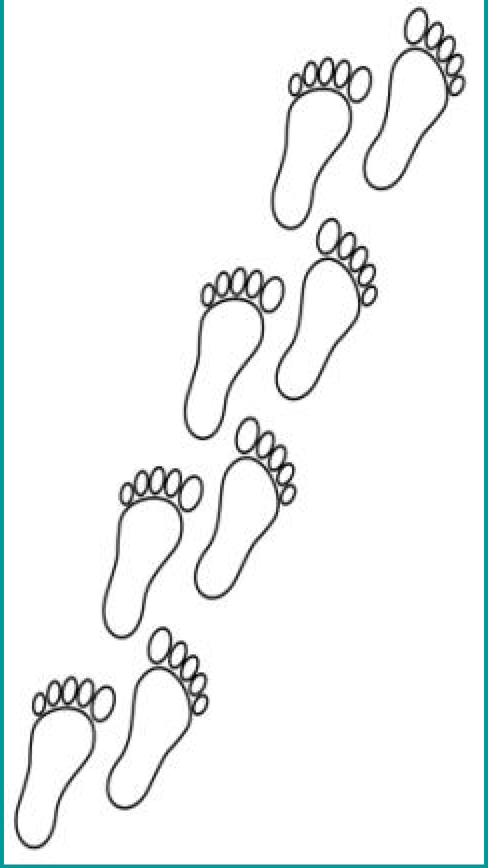


PATTERN conceptual framework

natural

ideal



abstract

Place

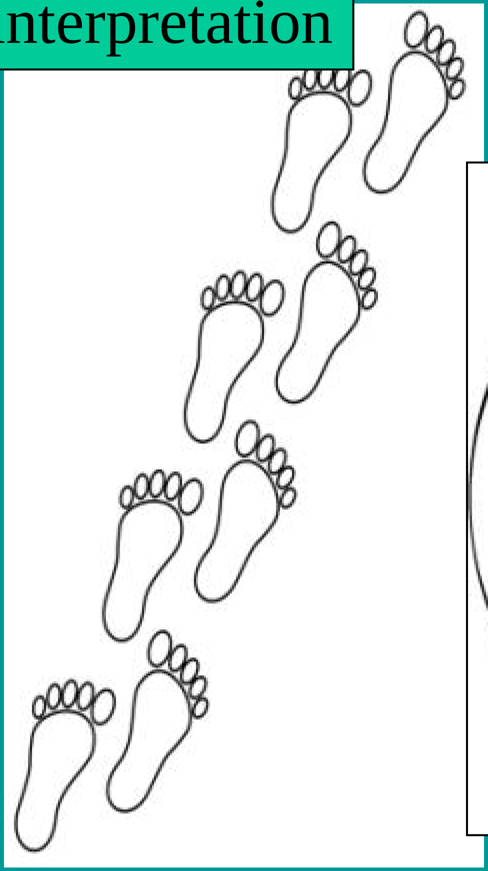
PATTERN conceptual framework

natural

observation

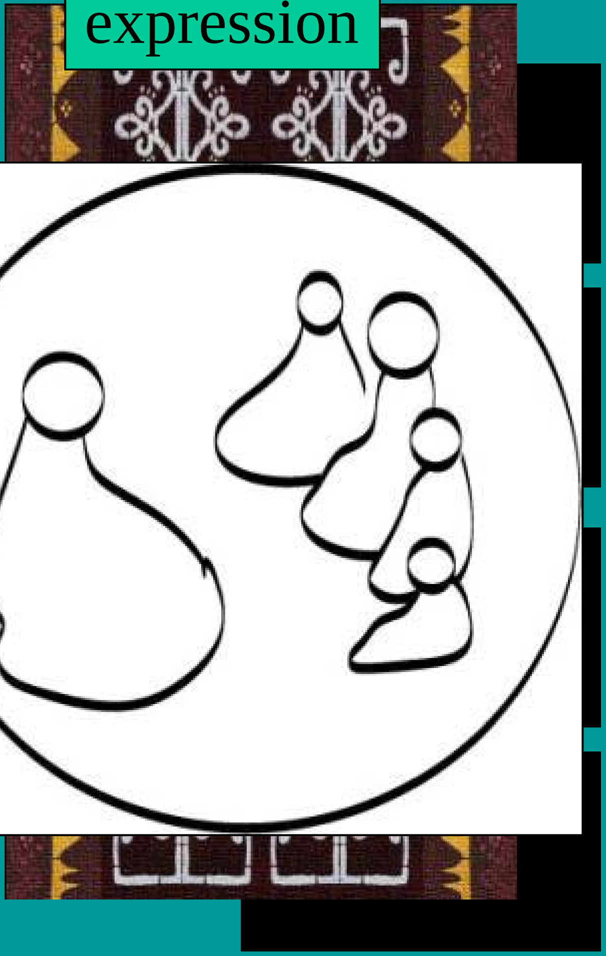
ideal

interpretation

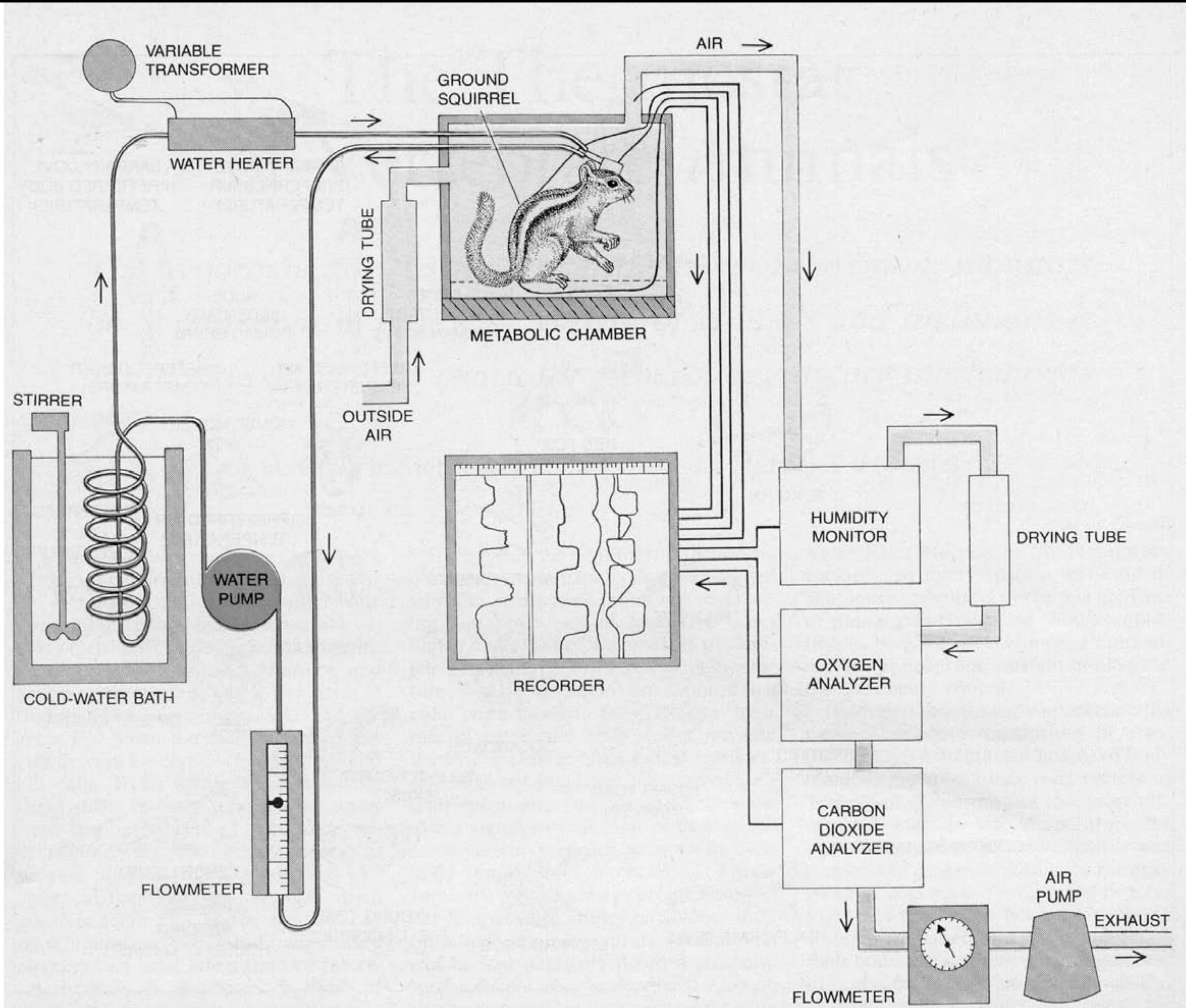


abstract

expression



Place


VARIABLE TRANSFORMER
GROUND SQUIRREL
AIR
WATER HEATER
DRYING TUBE
METABOLIC CHAMBER
STIRRER
OUTSIDE AIR
WATER PUMP
COLD-WATER BATH
RECORDER
HUMIDITY MONITOR
DRYING TUBE
OXYGEN ANALYZER
CARBON DIOXIDE ANALYZER
FLOWMETER
AIR PUMP
EXHAUST
FLOWMETER

21 August 2003

brief communications

Fibre-optical features of a glass sponge

Some superior technological secrets have come to light from a deep-sea organism.

Modern technology cannot yet compete with some of the sophisticated optical systems possessed by biological organisms[1–3]. Here we show that the spicules of the deep-sea 'glass' sponge *Euplectella* have remarkable fibre-optical properties, which are surprisingly similar to those of commercial telecommunication fibres — except that the spicules themselves are formed under normal ambient conditions and have some technological advantages over man-made versions.

The skeleton of the hexactinellid class of sponges is constructed from amorphous, hydrated silica[3–6]. *Euplectella* builds an intricate cage (Fig. 1a), which typically houses a mating pair of shrimp (hence its nickname, 'Venus flower-basket') and is composed of a lattice of fused spicules[4] that provide extended structural support.

A network of anchorage spicules (basalia) extend outwards in a crown-like formation. These spicules are generally 5–15 cm long and 40–70 μm in diameter; their native cross-section is homogeneous and they have no structural boundaries. Under stress or etching, the spicules reveal a characteristic layered morphology[8] and cross-sectional variations in composition that appear as three distinct regions: a pure silica core of about 2 μm in diameter that encloses an organic filament; a central cylinder that has the greatest organic content of the three; and a striated shell that has a gradually decreasing organic content and which is glued together by organic films (Fig. 1b).

We anticipated that the spicules' rich substructure should be reflected in their optical properties as well. Indeed, interferometric refractive-index profiling[7] revealed three regions that correspond to the three regions of structural composition (Fig. 1c): a core with high refractive index that is comparable to (or higher than) that of vitreous silica; a cylinder of lower refractive index that surrounds the core; and an oscillating pattern with progressively increasing refractive index at the outer part of the spicule.

To determine whether this typical 'core-cladding' refractive-index profile endows the spicules with wave-guiding properties, we investigated their transmission characteristics. We found that embedded spicules act as single- or few-mode waveguides — that is, light waves are effectively confined to the core, where refractive index is highest (Fig. 1d, left). When light was coupled into free-standing spicules, they functioned as multi-mode fibres, with most of the light filling the entire cladding, because of the enhanced refractive-index contrast between the spicule and air (Fig. 1d, right).

These biological fibres therefore resemble commercial telecommunication fibres, in that they are made of the same material and have comparable dimensions, as well as similar refractive indices for the high-index core and a low-index cladding. They also function as efficient single-mode, few-mode or multi-mode waveguides, depending on the optical launch conditions.

The principal weakness of commercial optical fibres is that they fracture as a result of crack growth, whereas the spicules' lamellar layers, connected by organic ligands at the fibre's exterior, provide an effective crack-arresting mechanism and enhance fracture toughness[6,8,9]. Another superior feature of the spicules is their formation under ambient conditions, a process that is regulated by organic molecules[10,11]. This ambient-temperature process, unlike the high-temperature manufacture of man-made fibres, allows the structure to be doped with specialized impurities that improve the refractive index and therefore the wave-guiding properties. Our preliminary elemental analysis shows, for example, that sodium ions are present throughout the spicules, particularly in the core. Although sodium ions (and many other additives) are desirable fibre-optic dopants, they present a manufacturing challenge, for example by causing devitrification at high temperatures.

Our results suggest the intriguing possibility that the spicules of *Euplectella*, beyond structural anchorage support, could also provide a highly effective fibre-optical network, which may be useful in distributing light in its deep-sea environment. This illuminating sponge should also shed light on low-temperature, biologically inspired processes that could give rise to better fibre-optical materials and networks.

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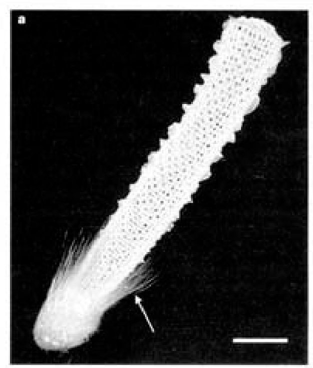


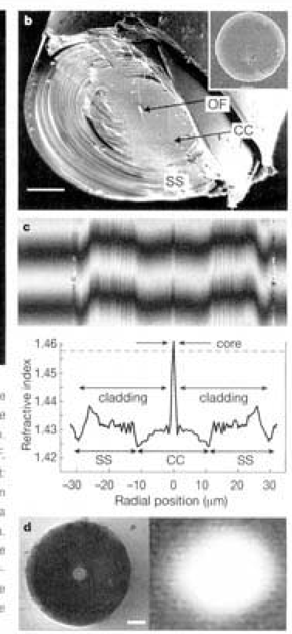


Figure 1 Structure and fibre-optical properties of spicules in the sponge *Euplectella*. **a,** The glass sponge, showing the basket-like cage structure and basalia spicules (arrow). Scale bar, 5 cm. **b,** Mechanically cleaved spicules show three structural regions. OF, organic filament; SS, outer striated shell; CC, central cylinder. Inset: smooth cross-section of a stress-free spicule. **c,** Interferogram (top) and corresponding refractive-index profile (bottom) of a spicule. Dashed line indicates the refractive index of vitreous silica. **d,** Wave guiding by individual spicules upon coupling with white light. Spicules embedded in epoxide act as single-mode or few-mode waveguides (left); free-standing spicules act as multi-mode waveguides (right). Scale bar, 10 μm. Further details are available from the authors.

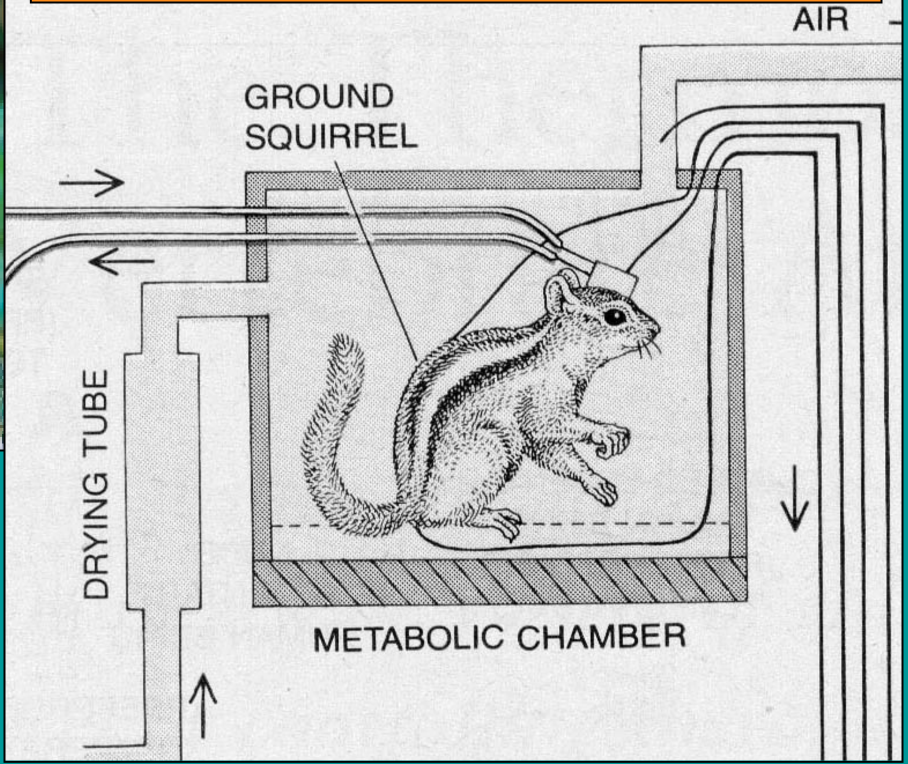
in the **patterns** of the animals
... lessons for humans

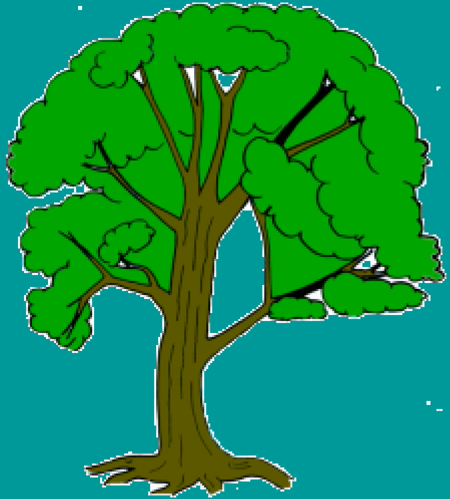
Squirrel

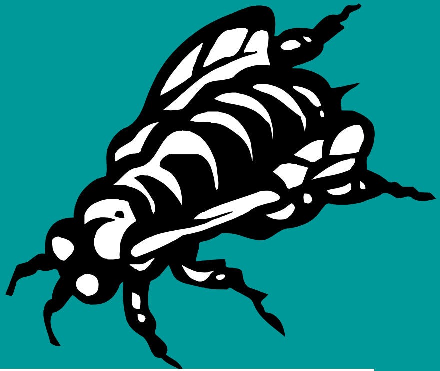
- shows courage by approaching humans and examining them while coming down trees
- shows courage when leaping several meters from tree to tree to new locations

Squirrel

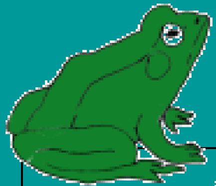
the squirrel







expression



Mother Earth

Thank you to…

UCCB
University College of Cape Breton

CIHR IRSC
Canadian Institutes of Health Research
Instituts de recherche en santé du Canada

ATLANTIC ABORIGINAL Health Research Program

ST. FRANCIS XAVIER UNIVERSITY

McGill

DALHOUSIE University

NOVA SCOTIA Health Research FOUNDATION

NSERC CRSNG

IWK Health Centre

Social Sciences and Humanities Research Council of Canada
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