EDUCATOR GUIDE

Observing your shark's braincase and brain

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Time to complete: 40-60 min

Age level: Grades 11-12 or College

Bloom's levels: 1, 2, 4 & 5

Description: In this module, your students will become familiar with the structure of the braincase and brain of the spiny dogfish shark (*Squalus acanthias*) through observation and understand why they have the shape that they do.

Materials needed:

- SA02 Student Guide & Notebook v1.0
- Dogfish Shark Skull Kit v1.0 **OR** Dogfish Neuroanatomy Kit v1.0

Systems:

- Nervous
- Skeletal

Core concepts:

- Morphological integration
- Structure & function

Competencies:

- Observation
- Scientific communication
- Scientific reasoning

Module ID: SA02

Module version: 1.1

Module sequence (suggested):

SA02 → SA03 → SA01 → SA05 → SA04

How to use and edit this module

This is an open-source active learning module created by 3D Anatomy Studios and licensed under CC NC-BY-SA for use with the Dogfish Shark Skull Kit or Dogfish Neuroanatomy Kit.

Module Structure

This module has an **Educator Guide**, a **Student Guide**, and a **Student Notebook** and is divided into one or more sections, each with a number, a motivating question as its heading, and a learning objective.

Educator Guide

The **Educator Guide** is intended for educators and contains a pedagogical schema for the module to help implement the module in a course (e.g., learning objectives, target Bloom's level and competencies, core concepts), an answer key for certain prompts/questions in the the **Student Notebook**, and module updates.

Student Guide

The **Student Guide** is intended for students to read as they complete the module's activities and can be read on a device or printed out.

Student Notebook

The **Student Notebook** contains worksheets or diagrams on which students can write or draw as a part of the module's activities. The **Student Notebook** can be printed out or filled in using a digital tablet.

Sharing and Editing

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Purchasing Kits

To purchase kits, please visit 3danatomystudios.com/shop/dogfish-skull-kit.

Pedagogical schema

Section 1. What is the anatomical orientation of the braincase and brain?

Learning objective	**Identify (Bloom's Level 1 - Remember)** the chondrocranium and brain and **interpret (Bloom's Level 2 - Understand)** their orientation and position relative to one another.
Activity	Observe models of the shark braincase and brain and fill in blanks on an anatomical conceptual image
Self-assessment	Compare fill-in-the-blank responses with possible responses in the student guide
Systems	**Skeletal**
Core concepts	**Structure & function**
Competencies	**Observation**

Section 2. What do you notice about the brain relative to the endocranial cavity?

Learning objective	**Explain (Bloom's Level 5 - Evaluate)** why the shark brain and endocranial cavity differ in their shape if provided with the brain and chondrocranium.
Activity	Observe models of the shark braincase and brain and write short answers
Self-assessment	Compare written responses with possible responses in the student guide
Systems	**Nervous** **Skeletal**
Core concepts	**Morphological integration** **Structure & function**
Competencies	**Observation** **Scientific communication** **Scientific reasoning**

Section 3. Which chondrocranium foramina could be for cranial nerves?

Learning objective	**Infer (Bloom's Level 4 - Analyze)** which foramina of the chondrocranium could convey cranial nerves out of the endocranial cavity.
Activity	Observe the foramina of a shark braincase model and write short answers
Self-assessment	Compare written responses with possible responses in the student guide
Systems	**Nervous**
Core concepts	**Structure & function**
Competencies	**Observation**

Section 4. Which of these foramina isn't like the others?

Learning objective	**Infer (Bloom's Level 4 - Analyze)** which foramen in the endocranial cavity corresponds to the vestibular nerve if provided with the chondrocranium and a pipe cleaner or light.
Activity	Observe the foramina of a shark braincase model and write short answers
Self-assessment	Compare written responses with possible responses in the student guide
Systems	**Nervous**
Core concepts	**Structure & function**
Competencies	**Observation**

Section 5. What differences do you notice among the cranial nerve foramina?

Learning objective	**Explain (Bloom's Level 5 - Evaluate)** the differences in relative size of the cranial nerve foramina if presented with the chondrocranium.
Activity	Observe the cranial nerve foramina of a shark braincase model and write short answers
Self-assessment	Compare written responses with possible responses in the student guide
Systems	**Nervous** **Skeletal**
Core concepts	**Structure & function**
Competencies	**Observation**

Answer key

Section 2. What do you notice about the brain relative to the endocranial cavity?

What do you notice about the brain relative to the endocranial cavity?

- The brain does not completely fill the endocranial cavity
- The brain is closer to the endocranial cavity walls in some places than in others
- The brain moves a bit inside the braincase if the braincase is shaken

What are one or more potential explanations for why the brain does not completely fill the endocranial cavity?

- There are other tissues surrounding the brain that are not represented in this model
- There is fat/adipose tissue surrounding the brain to cushion the brain during head impacts
- Additional space around the brain is needed for blood vessels or other tissues
- There is fluid surrounding the brain within the braincase that allows the brain to move within the chondrocranium
- As the shark develops and gets larger, the brain does not grow at the same rate as the braincase/chondrocranium

What explanation did you find in Yopak et al. 2019? Is it contrary to or compatible with your explanation?

- In some groups of sharks, the body grows at a faster rate than the brain, resulting in a brain that does not completely fill the endocranial cavity (low level of encephalization)

Does your previous explanation work for both sharks and humans? If not, can you revise your explanation so that it does?

- Humans are well known for having a high degree of encephalization (a large brain relative to body size) due to the human brain both evolving to be larger relative to body size (within primates) and growing larger over development within an individual. So the explanation for encephalization of brain vs. body growth could also explain the degree to which the brain fills the endocranial cavity in humans.

Section 5. What differences do you notice among the cranial nerve foramina?

What differences do you notice among the cranial nerve foramina?

- Different sizes
- Different positions
- Different orientations
- Different path lengths through the chondrocranium (some foramina form a longer "tunnel" through the chondrocranium)

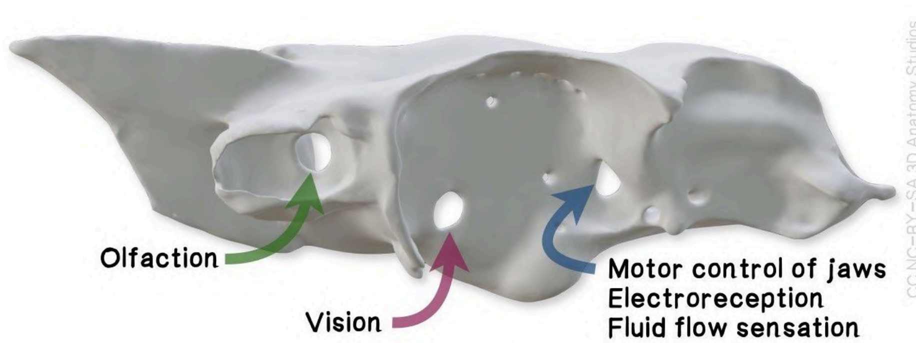
What are one or more potential explanations?

As the previous hint suggests, the diameter of a nerve is related to how much information it can carry and how quickly it can carry that information. Cranial nerves do not all need to carry the same amount of information at the same speed. Some structures send and receive more information than others and some information may be more important for quick decisions than other information. Therefore, cranial nerves differ in their diameter and thus so do the foramina that convey those cranial nerves. Note that the foramen cannot tell you the actual diameter of the cranial nerve(s) it conveys. A cranial nerve could be smaller than the foramen. However, it does tell you the maximum diameter of the cranial nerve at that point in the nerve's trajectory.

What information do you think is carried by the cranial nerves that pass through the three largest cranial nerve foramina of the braincase?

These three largest foramina convey cranial nerves that carry the following information (from rostral to caudal):

- Olfaction and chemosensation (from the olfactory organ)
- Visual information (from the retina of the eye)
- Electroreception, sensation of fluid flow on the skin, jaw motor control



Why? What do your three choices above all have in common?
All of these represent sensory information used to detect, catch, or defend against other animals, including potentially fast swimming prey or predators. A shark needs to receive a lot of this type of information and receive it quickly so that it has time to process the information, make a decision, and move accordingly. Thus, the corresponding cranial nerves, and the foramina they pass through, have large diameters.

Updates

Version 1.1

- Moved self-assessment for open-ended questions from the Student to Educator Guide.
- Added possible student responses for Section 2 to Educator Guide.