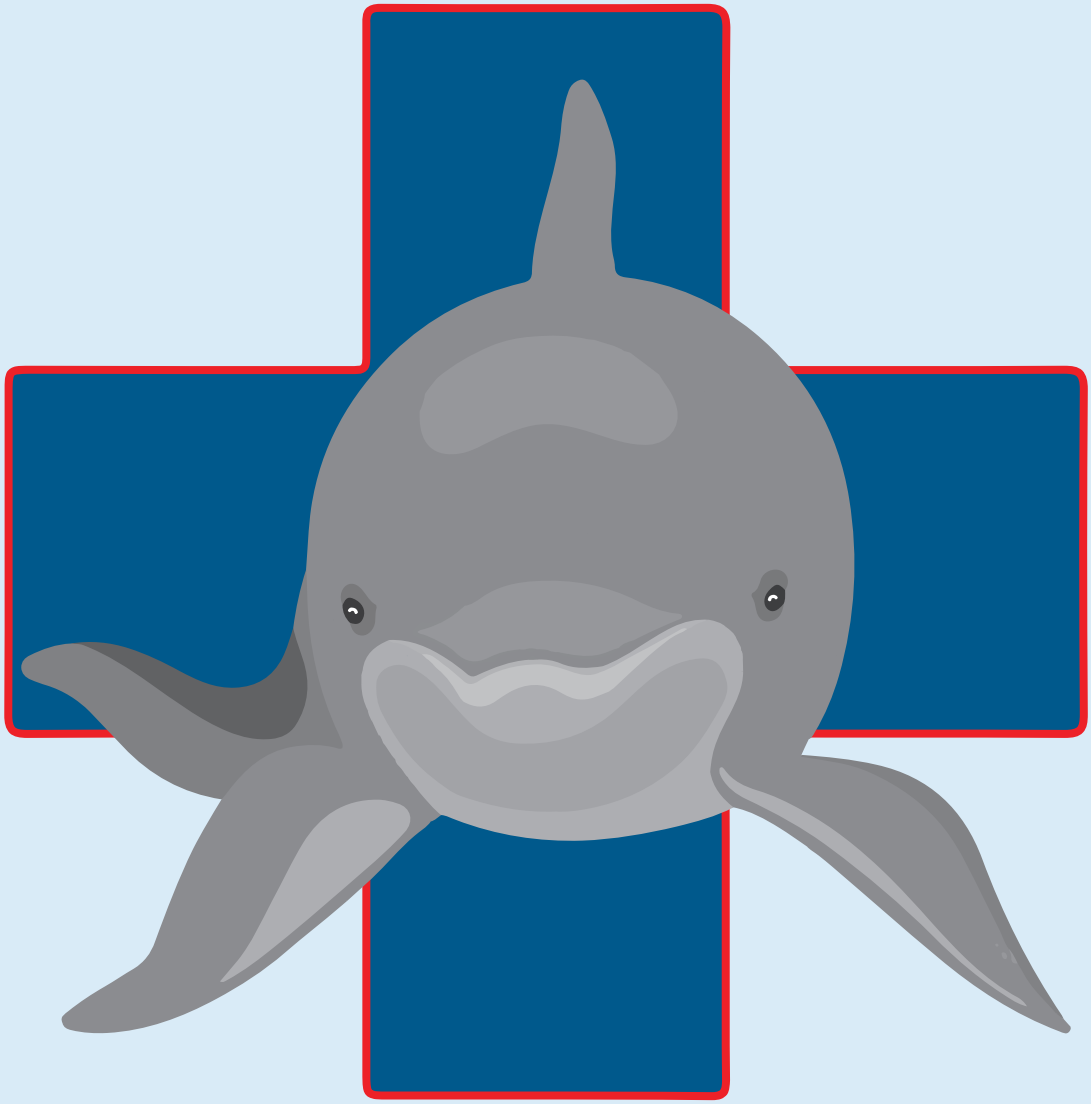
DOLPHIN DOCTOR



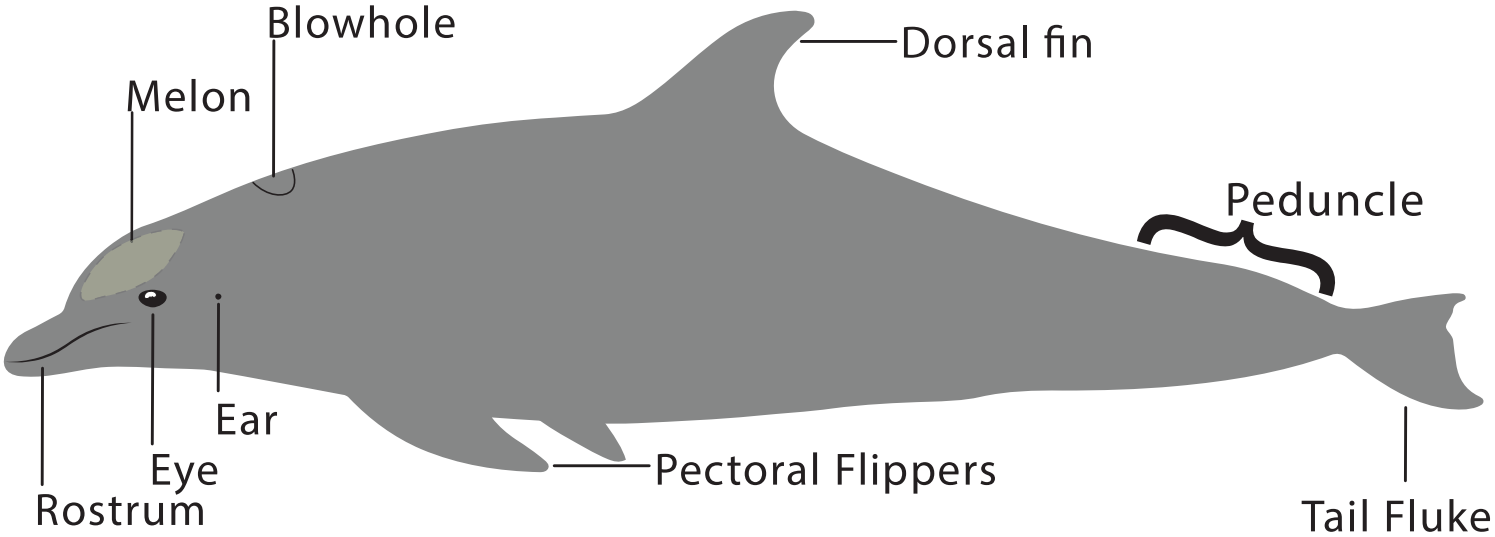
WORKBOOK

Middle School - High School Version

NATIONAL
MARINE MAMMAL
FOUNDATION

DOLPHIN DOCTOR

DOLPHIN ANATOMY

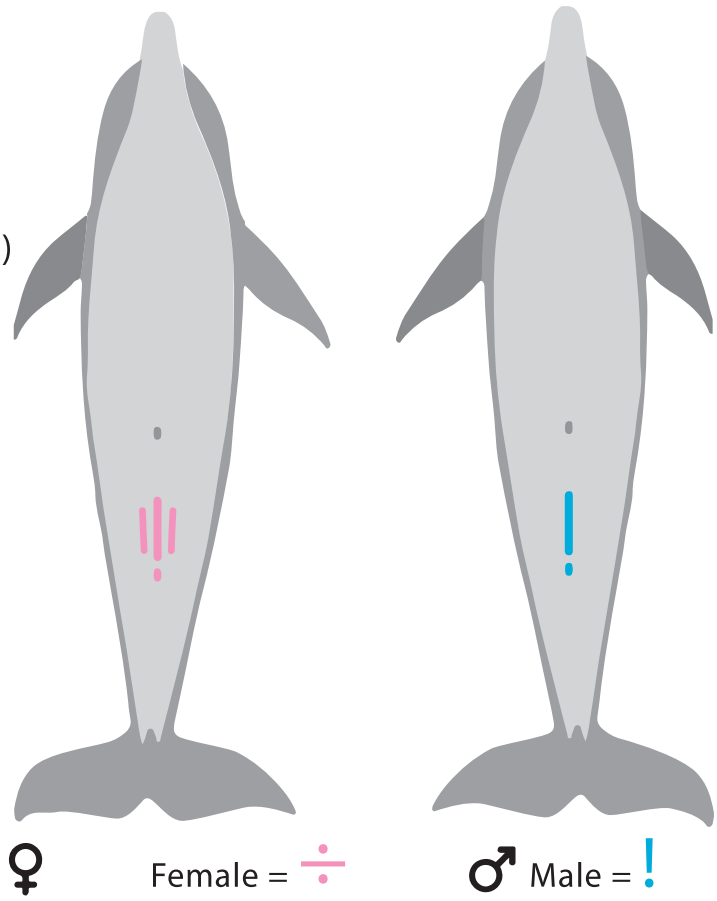


How do you tell a boy and girl dolphin apart? Look at their bellies!

(Hint: look for a divison sign or exclamation point!)

♀ Female = ÷

♂ Male = !

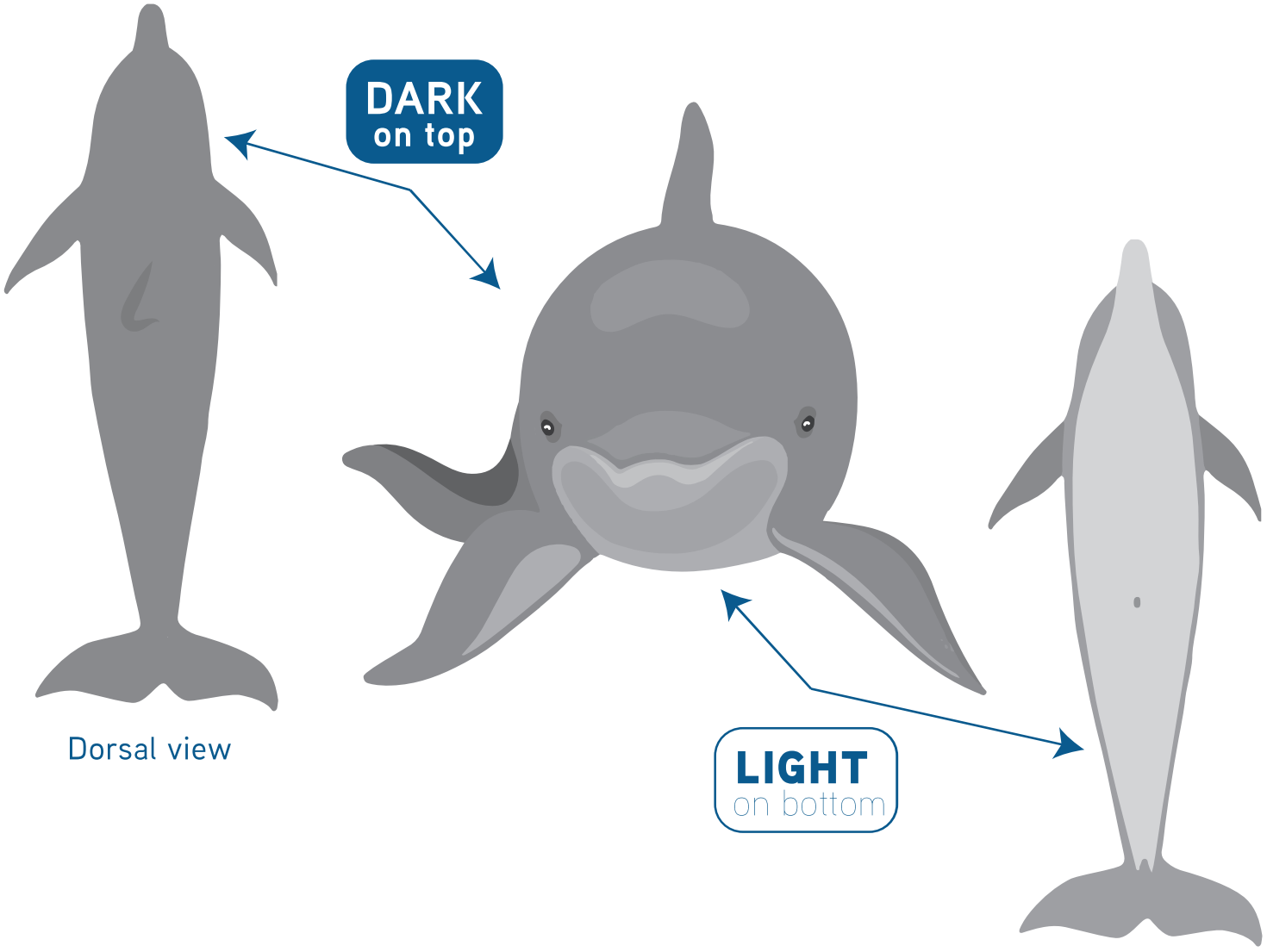


NATIONAL MARINE MAMMAL FOUNDATION

DOLPHIN DOCTOR

COUNTERSHADING
(THAYER'S LAW)

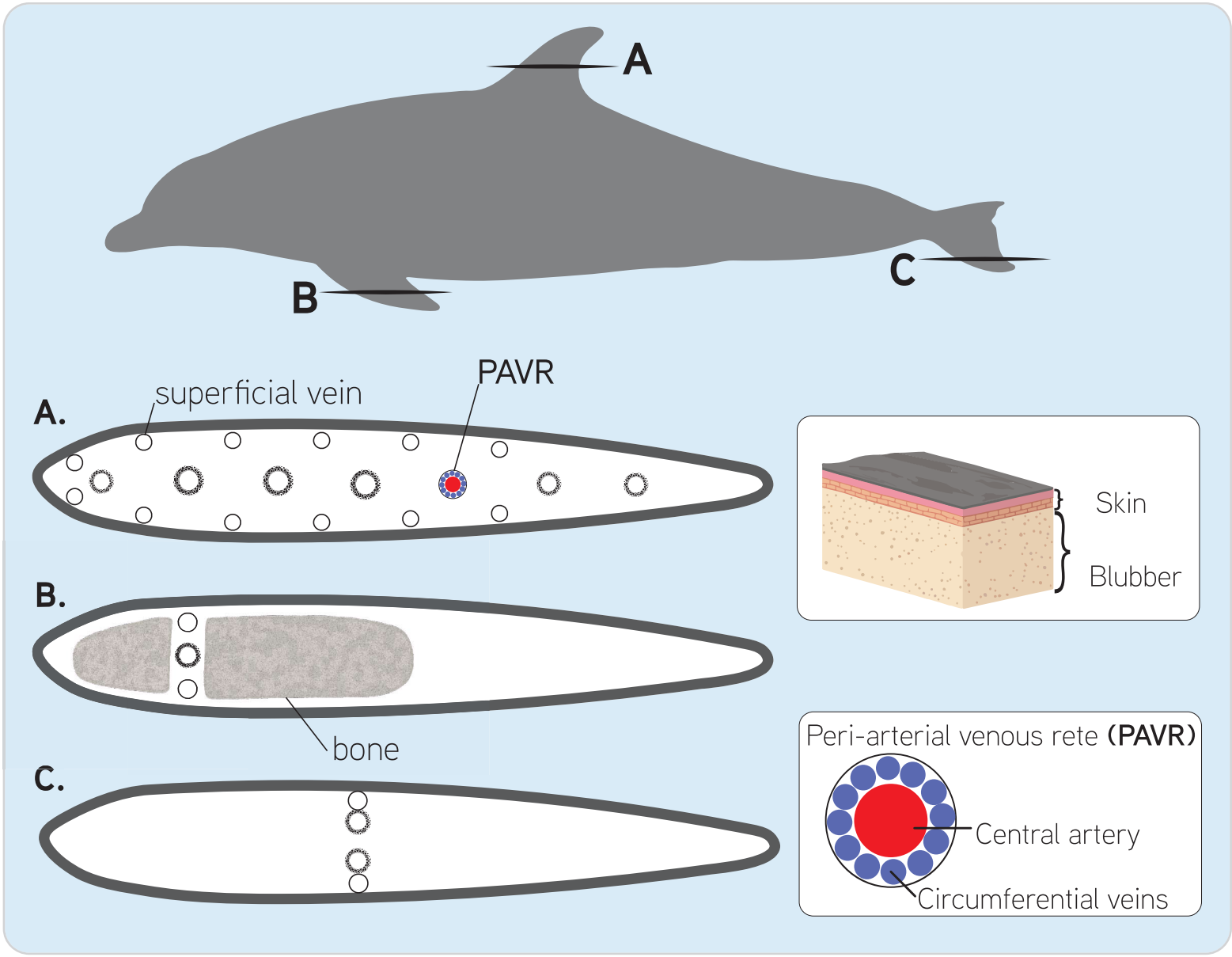
Dolphins have adapted to light penetrating the water from above. Countershading, or Thayer's law, is a method of camouflage in which an animal is darker on the upper side and lighter on the underside of the body. Dolphins use countershading to blend in with their environment. Looking down on them, the dark colors blend in with the ocean. Looking up from underneath, the patches of light and dark skin blend in with the sunlight penetrating the water. By being darker on top and lighter underneath, they help to conceal themselves from predators and prey.



THERMOREGULATION

COUNTERCURRENT HEAT EXCHANGE

A bottlenose dolphin's circulatory system adjusts to conserve or dissipate body heat and maintain body temperature.Thus, some heat from the blood traveling through the arteries is transferred to the venous blood rather than the environment. This countercurrent heat exchange aids dolphins in

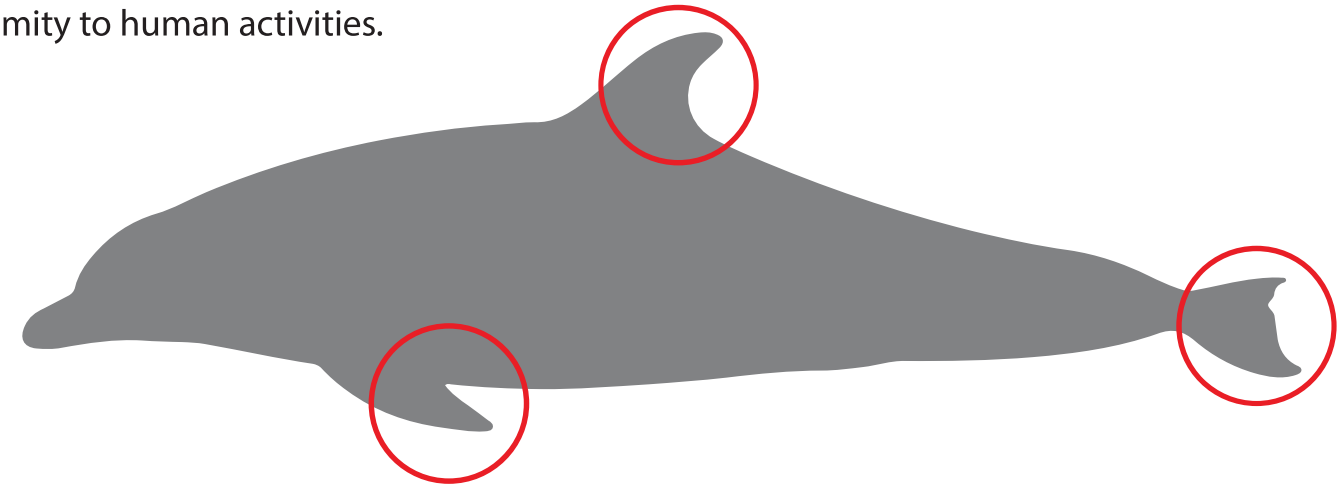


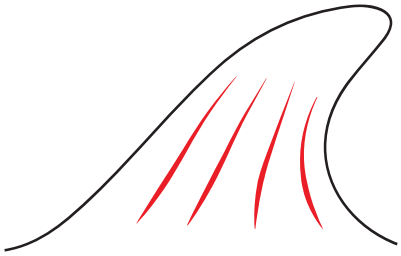
Schematic representations of countercurrent heat exchanges in bottlenose dolphins. Cross-sections through (A) the dorsal fin, (B) the pectoral flipper and (C) the flukes (modified from Pabst et al., 1999).

BLOOD SAMPLING SITES

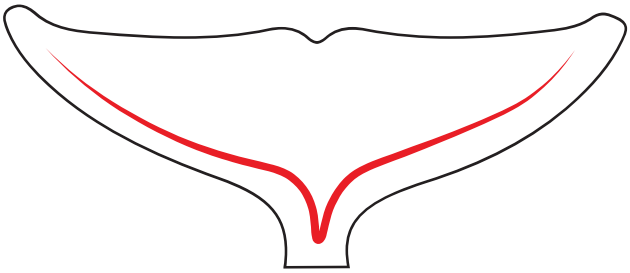
Bottlenose dolphins share many ecological and life history traits with humans. Some of these include long lifespans, similar reproductive cycles, such as giving birth to one offspring at a time and length of birthing intervals, fat stores that can concentrate toxicants, and top-predators feeding on similar food sources, such as fish and squid. To understand dolphin health and how it relates to human health, blood samples can be taken from the three common sites below, although it is most commonly drawn from the flukes.

Additionally, one way to monitor an ecosystem is to study sentinel species, or organisms that are indicators of the environment. Bottlenose dolphins are considered sentinel species and are ideal for biomonitoring because they can provide early warnings of ecosystem changes, and potential impacts to humans. Bottlenose dolphins also often inhabit coastal waters that are in close proximity to human activities.





Lateral surface of **dorsal fin**



Dorsal or ventral surface of **tail flukes** and **caudal peduncle**

Dorsal or ventral surface of **pectoral flipper**

DOLPHIN SOUND PRODUCTION

Sound travels in WAVES. The frequency of a sound wave is the number of wavelengths that travel past the ear in one second (measured in Hertz) . The intensity, or amplitude, of a sound wave is the loudness of a sound (measured in decibels). In other words, a change in pitch is a change in FREQUENCY while a change in volume is a change in AMPLITUDE.

In humans, very loud sounds above 90 decibels are damaging the inner ear and can even do irreversible damage above 120 decibels. Humans can hear frequencies of about 20 hertz to 20,000 hertz (number of vibrations per second). Sound waves of more than 20,000 hertz are known as ULTRASONIC and cannot usually be heard by humans. However, we can use ultra-sound in medicine, in ship navigation, and in industry.

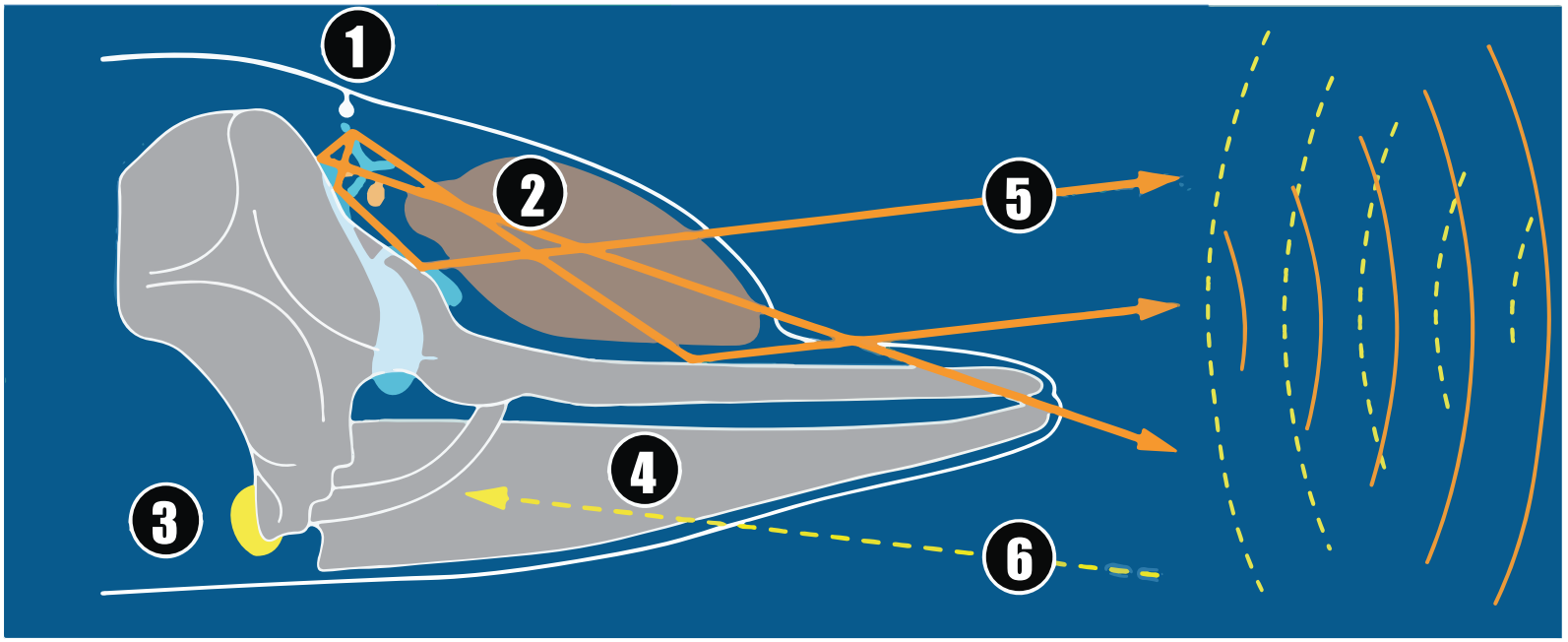
Sound is also used by various animals, including dolphins, bats, and some birds to perceive objects in their environment, which we call ECHOLOCATION. Sound moves 4X faster in water than in air, and most marine mammals rely on sound for communication, foraging, navigation and predator avoidance. Dolphins have a very sophisticated echolocation system that allows them to sense objects underwater even in very low visibility conditions. They can even use it to locate fish that are buried under the sediment on the ocean floor. The dolphin produces a sound (called a CLICK) and it travels through the bump that they all have on their foreheads - we call that the MELON. The melon acts like a cone, so it not only makes the sound LOUDER, it also focuses the sound in one direction. The click then travels through the water until it bounces off an object. That sound will ECHO back to the dolphin, through their lower jaw, or MANDIBLE, to the EARS.

But wait... I thought dolphins whistle? They do that too! Dolphins use their BLOWHOLES, not their mouths, to create whistles by forcing air through specialized muscles called PHONIC LIPS.

Scientists at the National Marine Mammal Foundation (NMMF) explore the sounds marine mammals make, the sounds they hear, and the effect of human-made sound has on them. They use special underwater microphones called HYDROPHONES to measure sounds underwater. NMMF scientists have also developed instrumentation that allows us to test the hearing of stranded wild marine mammals and determine the threshold criteria for exposure to sound that could affect marine mammal behavior and physiology, including hearing.

WORKSHEET: DOLPHIN SOUND PRODUCTION

Use the dolphin head schematic (A) to match each number to correspodning key word (C). Write the key word next to the correct number (B) and its function below.



1

2

3

4

5

6

KEY WORDS

Melon

Clicks

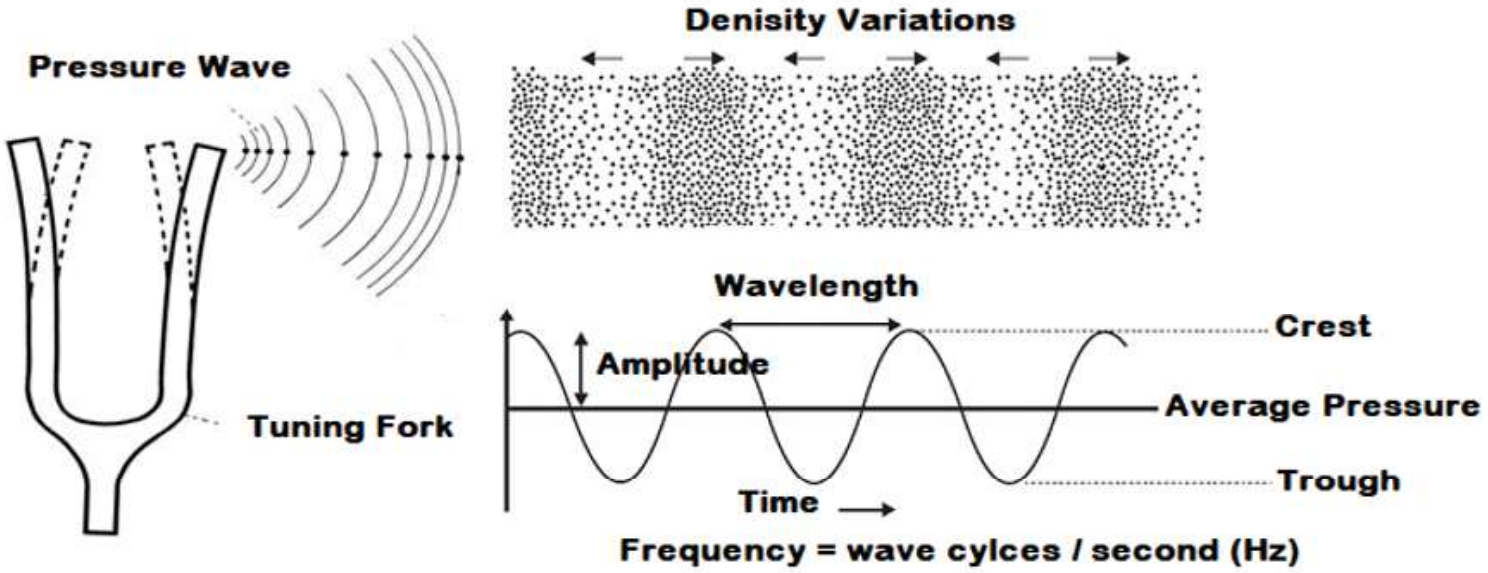
Echo

Mandible

Blowhole & Phonic Lips

Ear

LEARNING TO ANALYZE GRAPHS



SOUND WAVE ANALYSIS (Circle the correct answer)

1. Sound is:
   - A. vibrations of a compressible medium
   - B. photons of sound
   - C. noise measured in bels

2. There is no sound in a:
   - A. solid
   - B. vacuum
   - C. liquid

3. Sound travels:
   - A. slower in warm air than cold air
   - B. faster in solids and liquids than in air
   - C. faster in air than in water

4. The height of a wave is the:
   - A. trough
   - B. amplitude
   - C. wavelength

5. The distance from one crest of a wave to the next crest of a wave is:
   - A. wavelength
   - B. frequency
   - C. amplitude

6. The height of a sound wave indicates:
   - A. frequency of the sound
   - B. pitch of the sound
   - C. the loudness of the sound

7. The number of cycles or waves passing a particular point every second is the:
   - A. frequency
   - B. wavelength
   - C. volume

8. Frequency is measured in:
   - A. hertz
   - B. cycles per second
   - C. both of the above

9. The pitch of a sound (high or low notes) is determined by the:
   - A. talent of the singer
   - B. amplitude
   - C. frequency

10. Human hearing is between about:
   - A. zero and 10,000 hertz
   - B. 20 and 20,000 Hz
   - C. 20,000 and 25,000 decibels

WHO'S YOUR DOLPHIN DAD?

DNA Fingerprinting for Marine Mammals

Age Level: High School
NGSS Standards: HS-LS3-1 Heredity: Inheritance and Variation of Traits

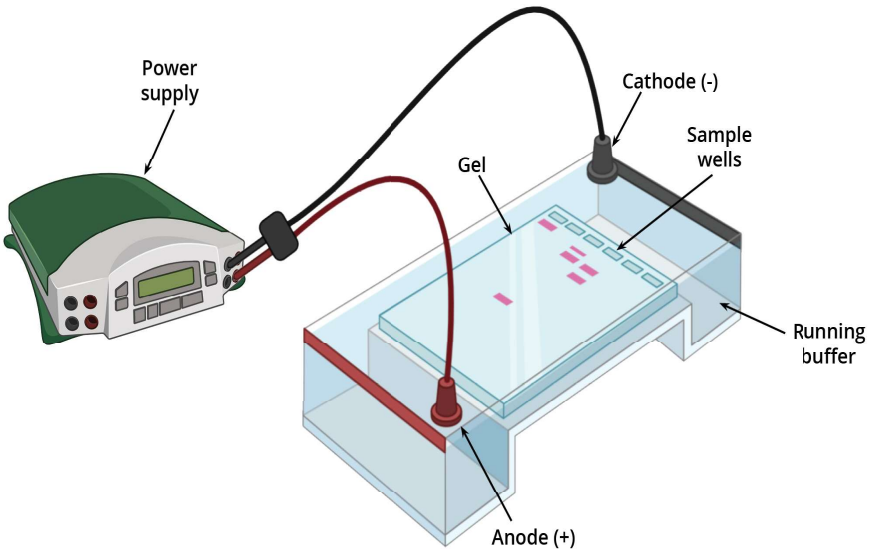
When a baby dolphin is born, it is often obvious who the mother is, but the father could be any of the males in the dolphin pod. Marine mammal veterinarians can use a DNA paternity test to determine which dolphin is the father. They use a method called DNA fingerprinting.

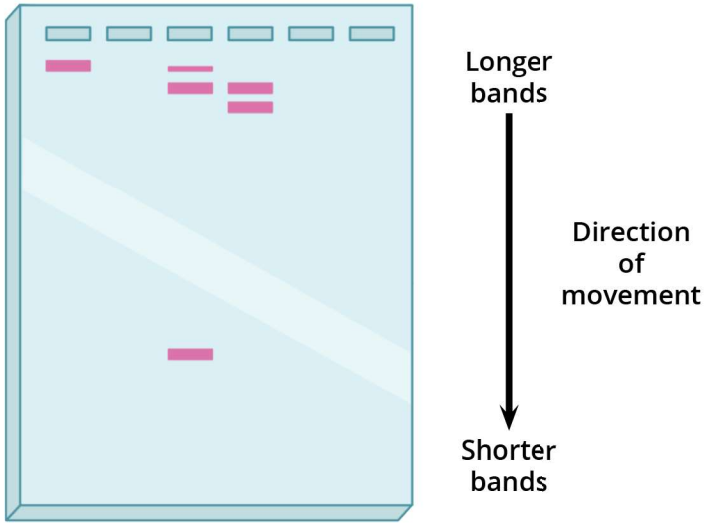
Any two animals, including humans, will have the vast majority of their DNA sequence in common, but within your DNA exist genetic clues to your heritage. Some of these clues are found in the non-coding regions of DNA where random mutations are relatively common. DNA fingerprinting is a technique used to distinguish between individuals of the same species using only samples of their DNA. DNA fingerprinting exploits highly variable repeating sequences called microsatellites. Since these minor changes do not usually affect genes essential to survival, the variations pass from parent to offspring. Over generations, these changes accumulate and the DNA regions develop distinct patterns. Two unrelated dolphins will likely have different numbers of microsatellites at a given locus. To analyze these DNA regions, scientists use a method of genetic profiling called DNA fingerprinting. DNA fingerprinting takes advantage of these inherited sequences, and uses them to identify the genetic similarities between certain individuals. Using this technology, family relationships can be identified on a genetic level and uncertainty about lineage can be resolved.

By using a technique called Polymerase Chain Reaction, commonly called "PCR", to detect the number of repeats at several loci, it is possible to establish a match that is extremely unlikely to have arisen by coincidence. The first step of PCR is to collect and isolate DNA from the animal. The DNA is then amplified, replicated billions of times, using PCR. The DNA is then cut with special enzymes and analyzed using a DNA separation technique called gel electrophoresis. When separated by gel electrophoresis, a banding pattern for each individual's DNA is created based on fragment size. This pattern can then be compared with the banding patterns of other individuals. The more similar banding patterns are, the higher the probability that individuals are related.

Microsatellites can also be used to understand the population structure of wild dolphin pods. DNA fingerprinting is the same method used in human paternity testing and forensic science, to match crime suspects to samples of blood, hair, saliva or semen.

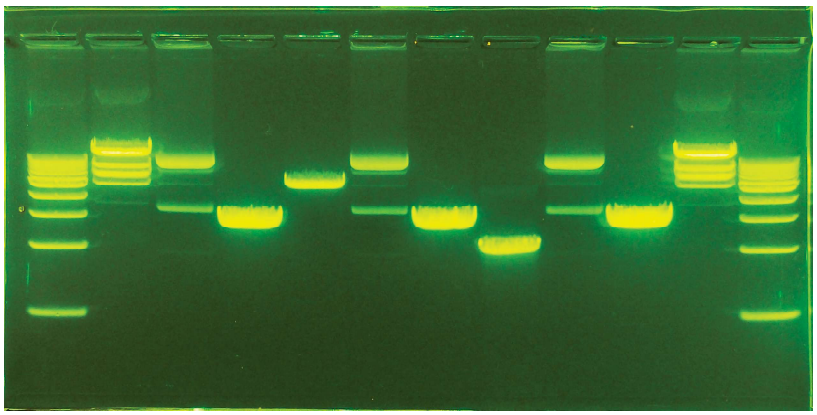
Electrophoresis is a technique used in many areas of science to analyze and separate samples by applying a constant electric field. Biologists or forensic scientists can use this technology to separate mixtures of DNA or dyes into each component based on size and electrical charge. One of the most commonly used and effective reagents for DNA separation is agarose. Agarose gels are usually cast in a tray with molten (melted) agarose. A comb is placed while the agarose is molten and then removed after the gel solidifies to create wells in which to load samples. A DNA stain is used to enable visualization of the DNA. As an electric field is applied to the agarose gel, the particles in the wells will begin to move. The direction that particles migrate depends on their charge. DNA has a negative charge, so it will be attracted to a positive electrode.





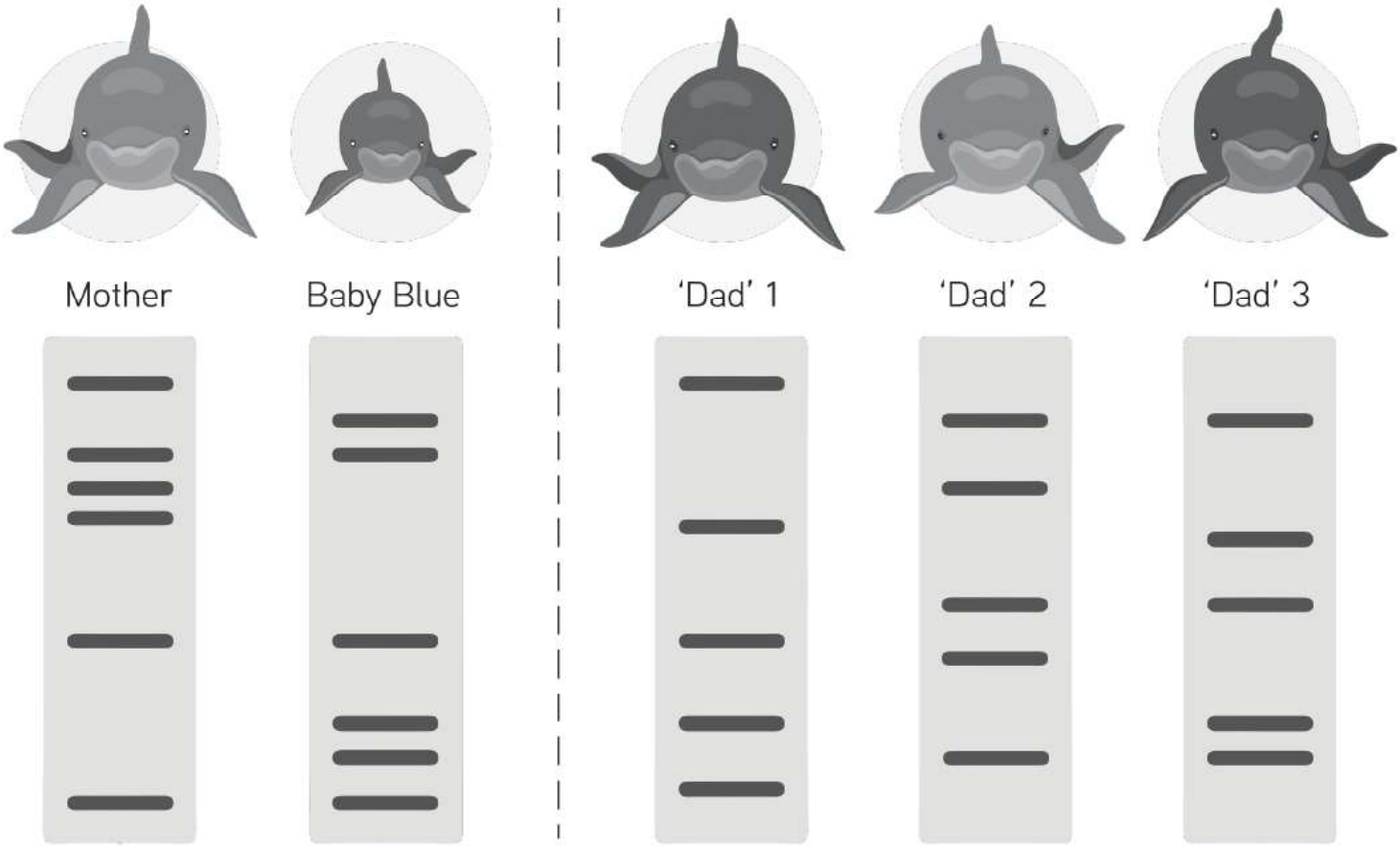
An illustration of gel electrophoresis workflow (figure made in BioRender, AAT Bioquest Inc..)

Picture of an actual agarose gel with bands of DNA



WORKSHEET: Your Turn!

The recent birth of a female dolphin calf named Baby Blue has given the research team an opportunity to gather more data about the dolphins' mating behaviors. By observing nursing behavior, they have already been able to match Blue with her mother. They have also narrowed down her father to one of three possible candidates based on observations made during the previous mating season, however they have yet to definitively link Blue to her father. Using a DNA fingerprinting technique, you are going to help them figure out which whale is Blue's father!



Questions

1. What is DNA and what does it do?

2. How much DNA do you share with each of your parents? How much DNA do you share with your siblings?

Parents:

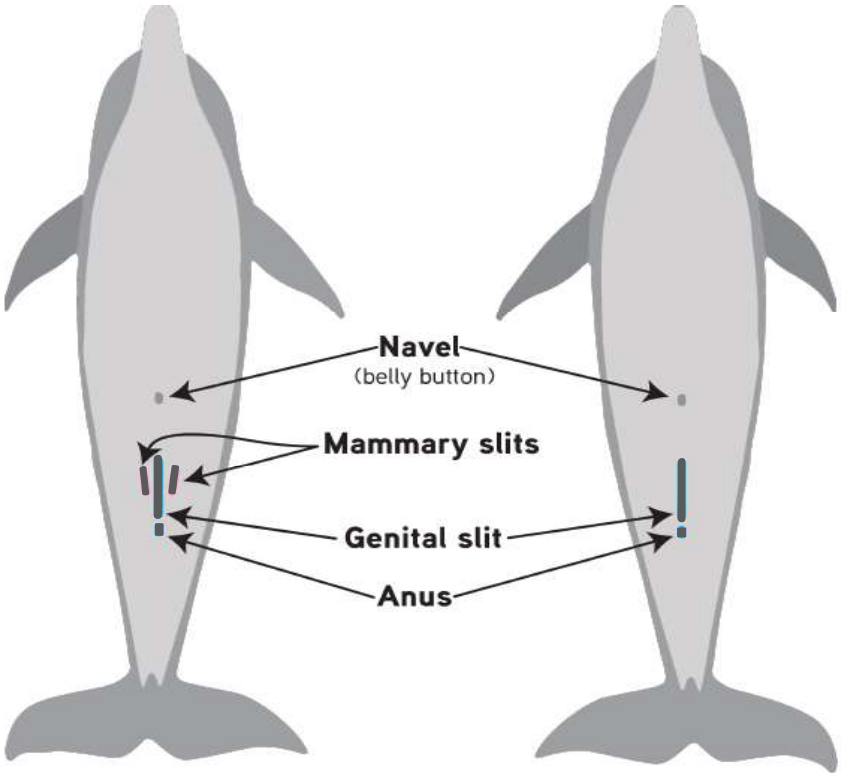
Siblings:

3. How many bands does Baby Blue have in her fingerprint? What about her mom? How many bands do they have in common?

4. Compare Baby Blue's fingerprint to each of the possible fathers. How many bands does Blue have in common with Male A? Male B? Male C? Who is most likely to be Blue's father? Justify your answer based on your data.

BONUS: How can you tell if a dolphin is male or female?

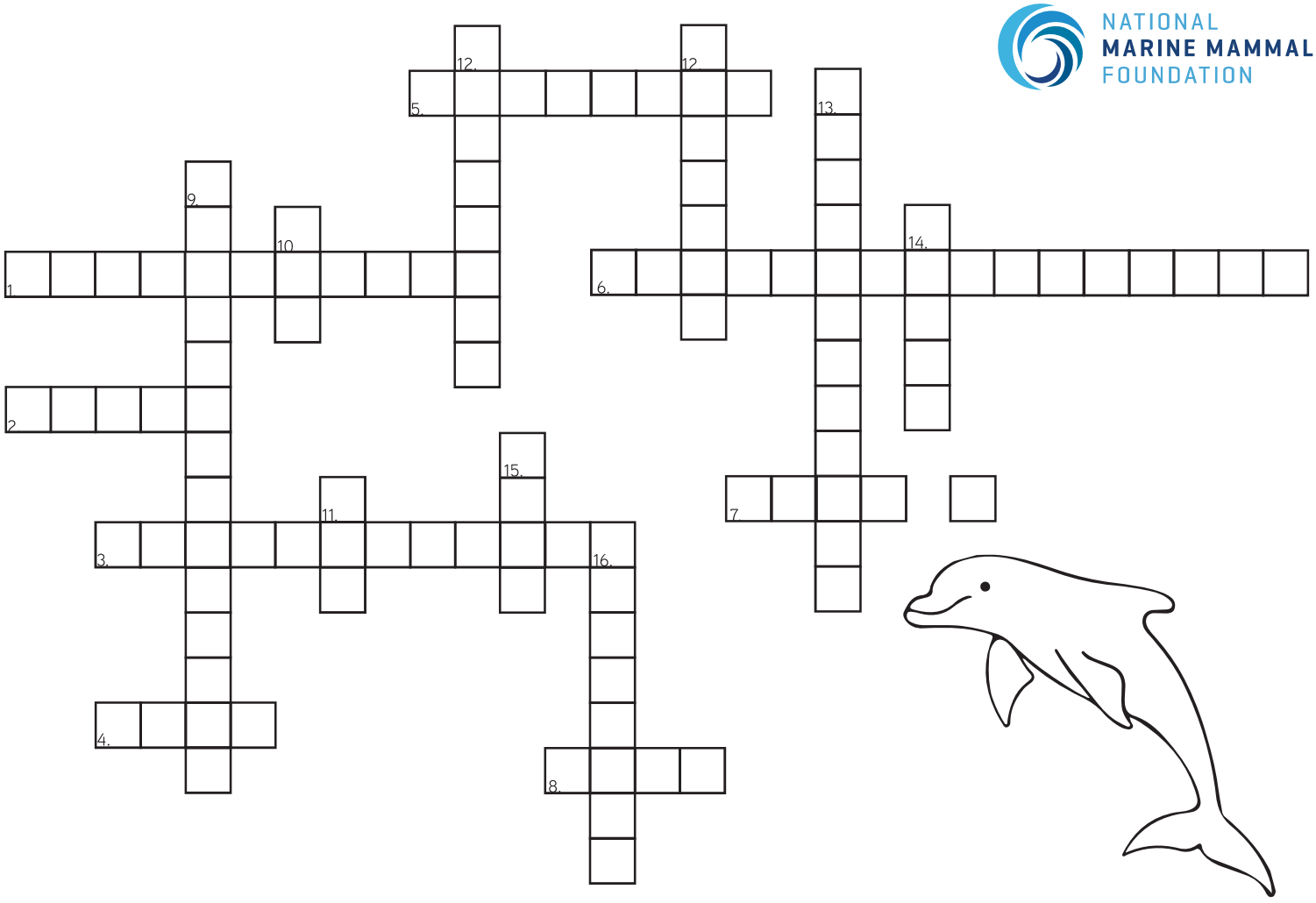
DNA analysis can also be used to tell if a dolphin is male or female. However, this is not often needed because it is possible to determine if a dolphin is male or female from the exterior of their body.



Circle one: Male / Female Circle one: Male / Female

DOLPHIN DOCTOR CROSSWORD PUZZLE

NATIONAL MARINE MAMMAL FOUNDATION



ACROSS

1. Dolphins use clicks and whistles to _____, or talk to one another!

2. A dolphin's tale is called a _____

3. Dolphins use sound and echoes to detect and locate objects. This is called _____, or bio sonar!

4. Dolphins use echolocation to _____ fish.

5. Dolphins breathe from their nose (or _____), located on top of their head.

6. Dolphins are warm blooded and use their ability called _____ to maintain their body temperature. Their dorsal fins and tail flukes release excess heat from the body!

7. Dolphins have hair, give birth to live young, and are warm blooded. This means dolphins are a type of _____ - just like you!

8. A baby dolphin is called a _____.

DOWN

9. Dolphins are a darker color on their backs to blend in with dark ocean depths, and a lighter color on their bellies to blend in with the bright surface. This form of camouflage is called _____.

10. Dolphins breathe _____ and can hold their breath for over 10 minutes! Dolphins also have more red blood cells, so they are able to carry more oxygen throughout their bodies!

11. A group of dolphins is called a _____.

12. Dolphins have a thick layer of fatty tissue called _____. This helps keep the dolphin warm and makes up 20% of their body weight!

13. The dolphin's torpedo-like shape makes it more _____, or able to move more efficiently in water.

14. The "bump" on a dolphin's head used to focus the animal's sounds in one direction during echolocation is called the _____.

15. Did you know: Dolphin _____ regenerates (or heals itself) 10-20 times faster than a humans' does!

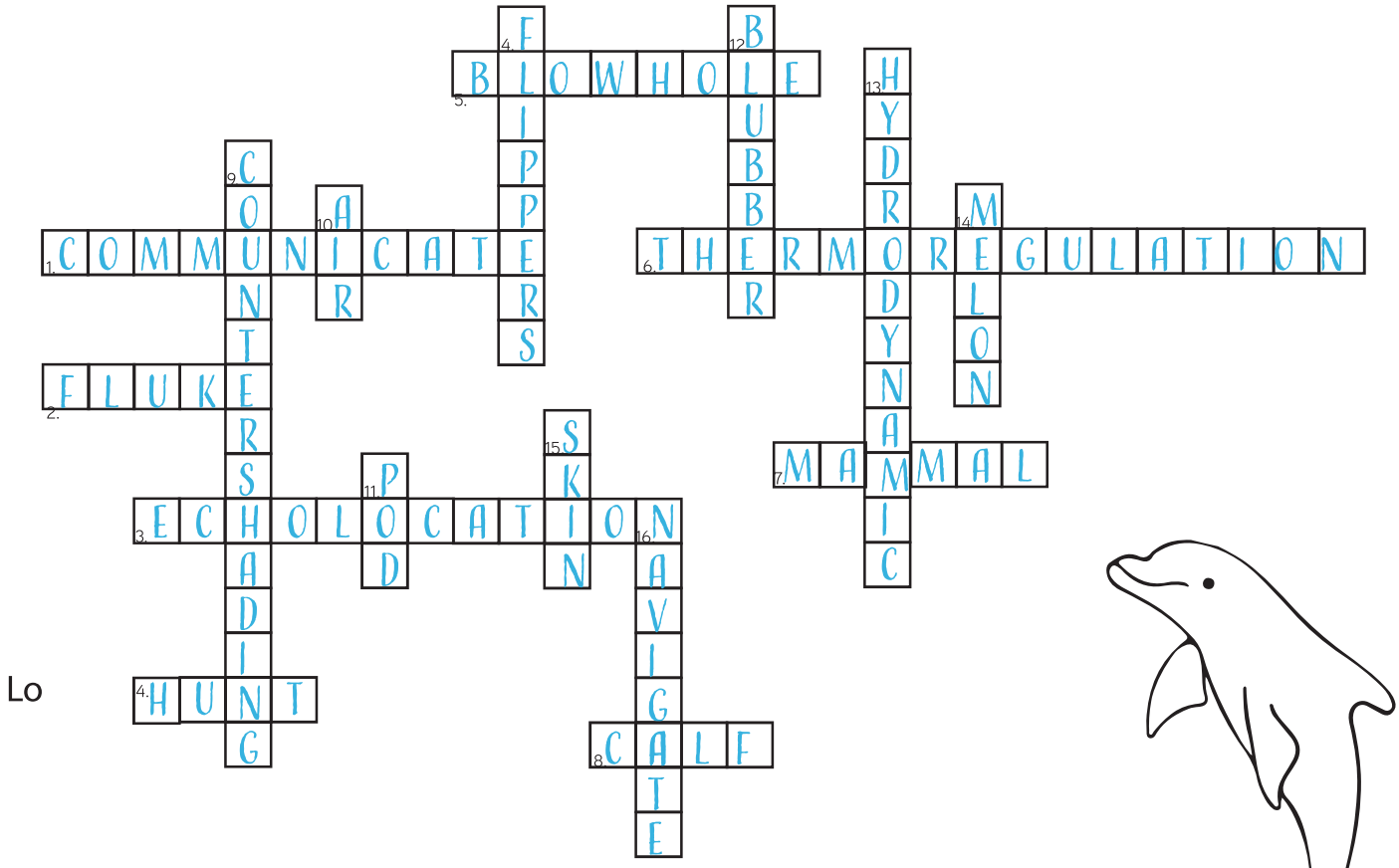
16. Dolphins also use echolocation as they travel and find their way through, or _____ , their environment.

ANSWER KEY

Page 6: Dolphin Sound Production: 1 (Blowhole & phonic lips), 2(Melon), 3(Ear), 4(Mandible), 5(Clicks), 6(Echo)

Page 7: Learning to Analyze Graphs - Sound Wave Analysis: 1(A), 2(B), 3(B), 4(B), 5(A), 6(C), 7(A), 8(C), 9(C), 10(B)

Page 12: Crossword Puzzle:



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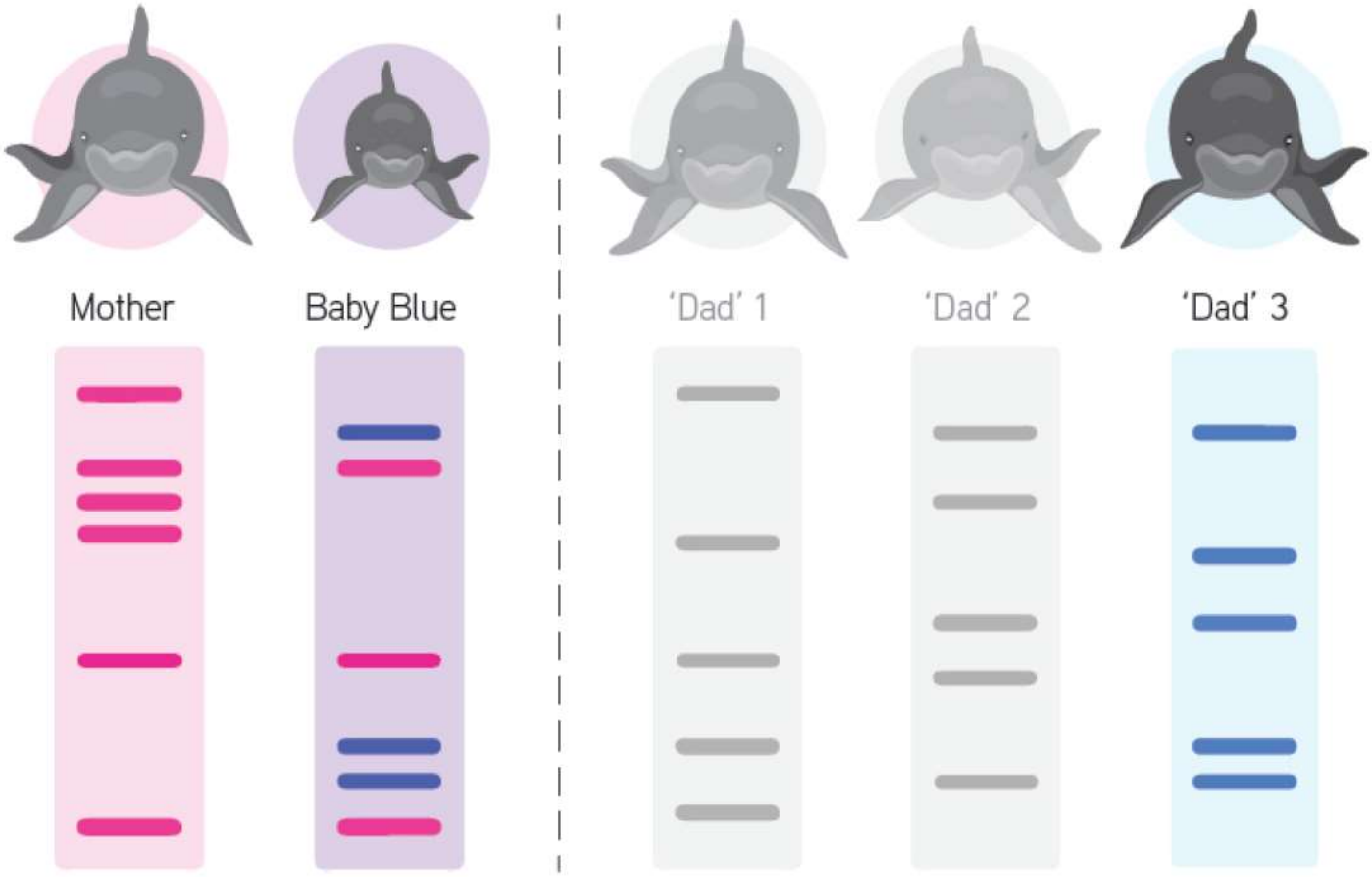
Page 10: Who's your dolphin dad?
Answer Key:



1. What is DNA and what does it do?

DNA stands for deoxyribonucleic acid. DNA is an extremely long macromolecule that is the main component of chromosomes. It is the material that transfers genetic characteristics from one organism to their offspring and exists in all life forms. The genetic information of DNA is encoded in the sequence of the bases and is transcribed as the two strands of the chromosome unwind and replicate.

2. How much DNA do you share with each of your parents? How much DNA do you share with your siblings?

You share ½ of your DNA with each of your parents. How much you share with your siblings depends on which chromosomes are passed to each sibling from each of their parents and it is usually between 38% - 61% (average is 50%).

3. How many bands does Baby Blue have in her fingerprint? What about her mom? How many bands do they have in common?

Baby Blue has six (6) bands in her fingerprint, and of those she shares three (3) with her mother.

4. Compare Baby Blue's fingerprint to each of the possible fathers. How many bands does Blue have in common with Male 1? Male 2? Male 3? Who is most likely to be Blue's father? Justify your answer based on your data.

Bands in common with:

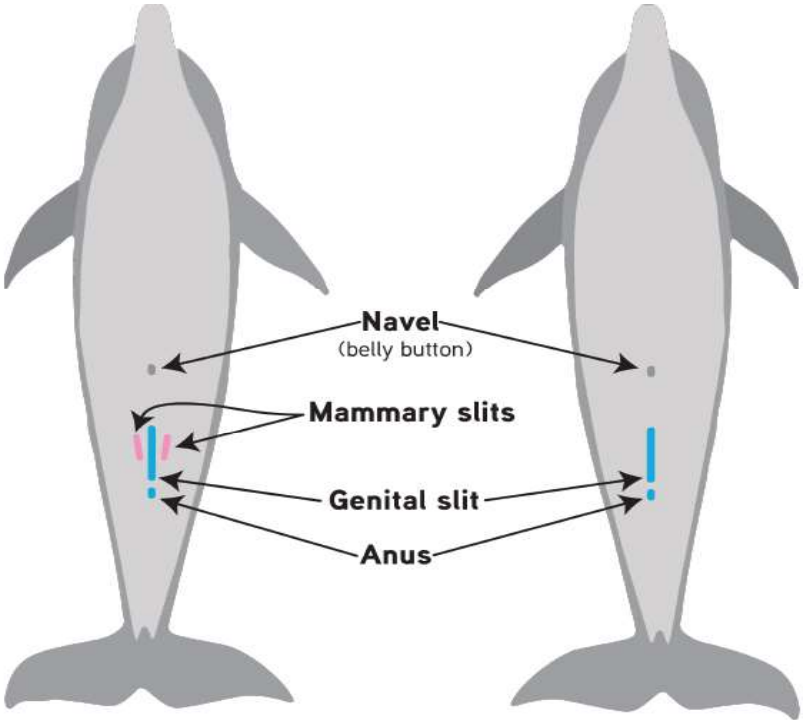
Male 1: 0-1

Male 2: 0-1

Male 3: 3

Male C is most likely to be Baby Blue's father because she shares three bands of DNA with him, which is approximately half of her bands.

BONUS:



Circle one: Male / Female

Circle one: Male / Female