HORSESHOE CRABS AROUND THE WORLD

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Grade Level: Middle and High School

Class Time: 2 class periods

Subjects: Biology, Ecology, Conservation

Materials: Access to the internet; Printout of Student Handout (attached); and Origami paper (optional)

OVERVIEW

This activity involves students in internet-based research to become experts on one of the four species of horseshoe crabs (HSCs) found around the world. Students will then present their findings to their class in one of several formats: a mini-brochure, short (three slide) PowerPoint presentation, or round-table discussion.

CONCEPTS

- There are four species of HSCs that currently exist worldwide: one off the east and gulf coasts of North America (*Limulus polyphemus*), and three in Asia (*Carcinoscorpius rotundicauda, Tachypleus gigas* and *Tachypleus tridentatus*).
- Each species has unique physical features, behavior and habitat preferences.
- Different countries and cultures have varying economic uses and values of the HSC. Human impact on HSC populations differs world-wide.
- The various cultures and countries have different levels of involvement in conserving HSC populations.

LEARNING OBJECTIVES

After participating in this activity, students will:

- Become experts on the biology, ecology and conservation of one of the four species of HSC that exist world-wide
- Explain/discuss the biology, ecology and conservation of their particular species with their classmates
- Convey knowledge of their assigned species via the creation of a mini-brochure, short PowerPoint or participation in a class discussion
- Gain a general understanding of the four species, how HSCs are utilized by humans world-wide, and what conservation efforts are present in different countries.

PROCEDURE

1. This activity is best used after students are somewhat familiar with the natural history, anatomy and conservation of the American horseshoe crab (Limulus polyphemus). Along with the video segments in Module One of GE&S, www.horseshoecrab.org is a great place to review key points on these topics. This site also has some information on the other three species of HSCs.

2. Students can be divided into several teams to research each of the four HSC species. Web addresses are provided in the **Student Handout**, as well as a chart to guide students' online research.

3. After completing their research, students will share what they have discovered using one of several possible formats:

   a) By creating a bi-fold brochure (on 8.5" x 11" paper) featuring the following information:

      - The Latin and common name of their species, the geographic distribution, and at least two photographs of their species and/or human interaction with their species.

      - The brochure should also include the most important facts discovered for each of categories in the Web Research Chart (found in the **Student Handout**).

   b) By creating a short PowerPoint slide presentation (three slides maximum) that includes the information mentioned in a) above; or,

   c) By sharing the information about their species with the class in a round table format, much like an article jigsaw where each group reads one article out of a number of articles and reports back to the class about the content of the article, so that the entire class is exposed to the content of all the articles.

4. Optional extension: Below is a link to instructions for making origami horseshoe crabs. Perhaps a fun Friday afternoon or "day before vacation" activity!
   http://www.squidoo.com/dollar-origami#module12298740

5. For High School Students (AP Biology and Honors Biology in particular): This activity can be extended by having your students read primary source papers on the biology, natural history and conservation of the different HSC species. Links to a variety of papers and resources have been included at the end of the **Student Handout**.

EVALUATION

Students will present their findings to their class in one of several formats: a mini-brochure, short (three slide) PowerPoint presentation, or round-table discussion.

RESOURCES/REFERENCES

Please see extensive list of internet links to articles at the end of the **Student Handout**

Student Handout: Horseshoe Crabs around the World

INTRODUCTION

Here in the Unites States, much is known about *Limulus polyphemus*, the American horseshoe crab (HSC). But did you know that there are three other species of HSCs living in waters elsewhere across the globe? As in the U.S., these other species of HSCs are intimately connected with humans and other species, and in some instances, there are active, ongoing conservation efforts to preserve the HSCs and educate the public as to their important role in the ecosystems in which they live.

In this activity you will be researching one of the four species of HSCs in order to become an expert on that particular species. Begin by using the links provided below to learn about your species.

Living Horseshoe Crab species:

Carcinoscorpius rotundicauda

Limulus polyphemus

Tachypleus gigas

Tachypleus tridentatus

PROCEDURE

1. Working with other members of your team, visit the websites below to become an expert on your particular HSC species. As you collect information, record it in the chart below.

2. Download and print a photograph of a member of your species. Be sure to include the reference for the site that you use.

3. After you have finished collecting your information, you will be sharing what you have learned with the rest of your class about your species via a format given to you by your teacher. Work with your team to best present your information in that format.

4. Optional Extension: Make your very own origami horseshoe crab!
   http://www.squidoo.com/dollar-origami#module12298740

Horseshoe Crabs Around The World – Web Research Chart

Species (Latin) name:	
Common name(s):	
Classification - kingdom through species:	
Geographic distribution (Where in the world does this species live?):	
Unique anatomical and behavioral features (as compared to other species of HSCs):	
Size range - males and females (How large do they get?):	
Does this species coexist with any other HSCs species? If so, which one(s)?	
Nesting habitat:	

How is this species used by humans?	
Threats to survival/ impacts on this species (e.g. climate change, shoreline development, etc.)	
Is this species considered endangered? What conservation efforts are currently underway to protect or preserve this species?	
Is there any current research involving the species?	
Interesting stories/legends/fun facts:	

Horseshoe Crabs Around the World: Internet Resources*

Do humans eat Horseshoe crabs?

http://muthir.blogspot.com/2010/02/vietnamese-cuisine-horse-shoe-crab.html
(cooking HSC and making HSC egg omlette)
http://horseshoecrab.org/press/2009/03/princely-dish-a-hit-at-eatery.pdf

Carcinoscorpius rotundicauda

http://www.eol.org/pages/393281
http://www.afcd.gov.hk/english/conservation/con_mar/con_mar_hor/con_mar_hor.html
http://www.opcf.org.hk/pdf/species/Horseshoe_Crab.pdf
http://www.wildsingapore.com/wildfacts/arthropoda/limulidae/carcinoscorpius.htm
http://www.ecologyasia.com/news-archives/2003/jun-03/straitstimes_030629_1.htm
http://mangrove.nus.edu.sg/guidebooks/text/2076.htm
http://www.nus.sg/Resrch/gallery/html/clone.htm
http://www.hku.hk/ecology/porcupine/por16/huang.htm
http://www.hku.hk/ecology/porcupine/por20/arthropods.htm
http://www.hku.hk/ecology/porcupine/por18/crabs.htm
http://habitatnews.nus.edu.sg/index.php?entry=/marine/20090529-xiphosuran_rescue.txt
http://www.wildsingapore.com/wildfacts/arthropoda/limulidae/limulidae.htm
http://rms1.agsearch.agropedia.affrc.go.jp/contents/JASI/pdf/society/34-3054.pdf
http://www.springerlink.com/content/g0286751238v4143/
http://www.tm.mahidol.ac.th/seameo/2008_39_2/17-4183.pdf
http://cat.inist.fr/?aModele=afficheN&cpsidt=2927619
http://mangrove.nus.edu.sg/pub/seashore/text/175.htm
http://www.childrenshospital.org/newsroom/Site1339/mainpageS1339P1sublevel425.html

Tachypleus tridentatus

http://www.eol.org/pages/393279
http://www.afcd.gov.hk/english/conservation/con_mar/con_mar_hor/con_mar_hor.html
http://www.opcf.org.hk/pdf/species/Horseshoe_Crab.pdf
http://www.hku.hk/ecology/porcupine/por16/huang.htm
http://library.thinkquest.org/J0110020/Japanese.html
http://library.thinkquest.org/J0110020/museum.html (also look at “an explanation of the exhibits” link under “In Japan”)
http://www.answers.com/topic/japanese-horseshoe-crab
http://www.ceoe.udel.edu/horseshoecrab/fisheries/habitatchange.html
http://www.tachypleus_tridentatus.totallyexplained.com/
http://www.malaysiabest.net/2009/03/22/have-you-eaten-a-horseshoe-crab-before/
http://www.hku.hk/ecology/porcupine/por20/arthropods.htm
http://www.hku.hk/ecology/porcupine/por18/crabs.htm
http://www.childrenshospital.org/newsroom/Site1339/mainpageS1339P1sublevel425.html

Tachypleus gigas

http://www.eol.org/pages/393280
http://www.springerlink.com/content/u6l17g2338318515/
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC191604/
http://timesofindia.indiatimes.com/india/Crabs-grab-government-attention/articleshow/1219874.cms?curpg=1
http://www.oocities.com/vu3ybm/horseshoecrab.html
http://www.opcf.org.hk/pdf/species/Horseshoe_Crab.pdf
http://www.hku.hk/ecology/porcupine/por16/huang.htm
http://www.wildsingapore.com/wildfacts/arthropoda/limulidae/limulidae.htm
http://www.wildsingapore.com/wildfacts/arthropoda/limulidae/tachypleus.htm
http://mangrove.nus.edu.sg/pub/seashore/text/175.htm
http://www.childrenshospital.org/newsroom/Site1339/mainpageS1339P1sublevel425.html

Limulus polyphemus

http://www.eol.org/pages/393278
http://www.horseshoecrab.org
http://www.ceoe.udel.edu/horseshoecrab/
http://www.dnr.state.md.us/education/horseshoecrab/
http://marinebio.org/species.asp?id=281
http://www.dnr.maryland.gov/education/horseshoecrab/threats.html
http://www.opcf.org.hk/pdf/species/Horseshoe_Crab.pdf
http://www.ceoe.udel.edu/horseshoecrab/fisheries/habitatchange.html
http://www.childrenshospital.org/newsroom/Site1339/mainpageS1339P1sublevel425.html

How to make an origami horseshoe crab

http://www.squidoo.com/dollar-origami#module12298740

Origami horseshoe crab using a dollar bill

Part 1 - http://www.youtube.com/watch?v=tv6cZG4D0k4
Part 2 -http://www.youtube.com/watch?v=g6KM10YIiEg&NR=1
Part 3 - http://www.youtube.com/watch?v=jVWikv0Rc9k&NR=1

Origami *Tachypleus tridentatus*

http://gallery.origami.com/main.php/images-origami-dot-com-originals/16_horseshoe.jpg.html

* these links were functional at the time of lesson development; it is possible (even likely) that some of them will no longer be operative at the time of its use, but a careful key word web search should put you in touch with comparable, or even newer, sources of information. All sources contain scientifically valid content and information.

HSCs Around The World - Web Research Answer Key *C. rotundicada*

Species (Latin) name:	*Carcinoscorpius rotundicauda*
Common name(s):	Mangrove horseshoe crab Japanese HSC Chinese HSC
Classification - kingdom through species:	Kingdom: Animalia; Phylum: Arthropoda; Class: Merostomata; Order: Xiphosura; Family Limulidae; Genus: Limulus; Species: *Limulus polyphemus*
Geographic distribution (Where in the world does this species live?):	*C. rotundicauda* is found in the Indo-Pacific region from the Bay of Bengal to Indonesia and Borneo, including Thailand, Vietnam and SE Indonesia. Specifically it lives in the inshore waters of the Indo-West Pacific and the mangrove-mudflat ecosystem.
Unique anatomical and behavioral features (as compared to other species of HSCs):	The telson (tail) is smooth and circular in cross-section. Sea grass beds are often important nursery grounds. Not much is known about the ecology of the juveniles. Shell is brown in color.
Size range - males and females (How large do they get?):	Average length: 30cm; Prosomal width up to 15cm Two species are common throughout South East Asia - the small and smooth-tailed *Carcinoscorpius rotundicauda* (diameter up to 15cm) and the larger triangular and serrated-tailed *Tachypleus gigas* (diameter up to 25cm).
Does this species coexist with any other HSCs species? If so, which one(s)?	Found in Singapore along with *Tachypleus gigas*. In Hong Kong, *C. rotundicauda* and *T. tridentatus* are usually co-existent and share the same habitats, particularly along the shores of Deep Bay.
Nesting habitat:	*C. rotundicauda* lays eggs in muddy sand or in the mud on the flat slopes of freshwater stream or river banks. Adults are also found in undisturbed mangroves areas.
How is this species used by humans?	In some regions, eggs are eaten, though there are reports of the eggs being toxic in some sub-populations. The female is cooked and then the unlaid eggs are removed and eaten.

Threats to survival/ impacts on this species (e.g. climate change, shoreline development, etc.)	• Based on eyewitness/anecdotal accounts in Singapore waters, numbers appear to have depleted significantly since the 1980's. This is due to habitat loss &increased pollution over 3 decades along the Johor Straits. • No regulations on near-shore fishing, nor is there any sort of law protecting the populations located in mangrove and mudflat areas.
Is this species considered endangered? What conservation efforts are currently underway to protect or preserve this species?	• *C. rotundicauda* is listed as 'Vulnerable' on the Red List of threatened animals of Singapore. • There are several educational initiatives promoted by specific environmental organizations aimed at promoting the conservation of HSCs.
Is there any current research involving the species?	• A husband-and-wife team at the National University of Singapore has genetically engineered a copy of an enzyme found in horseshoe crabs' blood. This protein is being marketed commercially as the diagnostic tool PyroGene. • Up to this point, the HSC had been the only source of this enzyme, Factor C, which is used to test for contaminants in injectable drugs and vaccines, artificial limbs and implants, and dialysis and intravenous drips • (Factor C is a key component of LAL)
Interesting stories/legends/fun facts:	Answers will vary, depending on what students find interesting. Some possible interesting facts include: • Several incidents of humans becoming ill after eating HSC eggs in Vietnam, Thailand and China have been well-documented. The cause of the toxic reaction is the compound tetrodotoxin. Fatal poisonings occasionally occur after eating the eggs of *C. rotundicauda* (due to respiratory paralysis). • Because male HSCs hold on to and follow potential mates around for long periods of time before eggs are laid. Not surprisingly, some locals associate HSCs with matrimonial fidelity (i.e. mating for life).

HSCs Around The World – Web Research Answer Key *T. tridentatus*

Species (Latin) name:	*Tachypleus tridentatus*
Common name(s):	Japanese horseshoe crab Chinese HSC
Classification - kingdom through species:	Kingdom: Animalia; Phylum: Arthropoda; Class: Merostomata; Order: Xiphosura; Family Limulidae; Genus: Tridentatus; Species: *Tachypleus tridentatus*
Geographic distribution (Where in the world does this species live?):	*Tachypleus tridentatus* is found in the waters surrounding South East Asia, from the Philippines to the southwestern seas of Japan. This region includes Malyasia, W Indonesia and China East Coast. *T. tridentatus* is the only HSC species found off the coast of Japan.
Unique anatomical and behavioral features (as compared to other species of HSCs):	Juveniles spend their early years living on mud flats and sand flats. They burrow into in sand or mud during high tides and dig out to feed on the exposed shore during low tide. Juvenile *T. tridentatus* do not leave their nest after hatching and usually spend their first winter in the nests.
Size range - males and females (How large do they get?):	*T. tridentatus* is the largest of the three Asian species. Adult crabs are generally longer than 40 cm and maximum length measurements seem to vary, study to study and range from 70 to as long as 92 cm.
Does this species coexist with any other HSCs species? If so, which one(s)?	Yes, all three Asian species can be found in the waters off Hong Kong (*Tachypleus tridentatus, T. gigas and Carcinoscorpius rotundicauda*).
Nesting habitat	*Tachypleus tridentatus* mates and lays eggs on sandy or pebbly beaches at high tide.
How is this species used by humans?	Served in seafood restaurants – both meat and eggs are eaten. Also used for biomedical purposes
Threats to survival/ impacts on this species (e.g. climate change, shoreline development, etc.)	Coastal development - results in the loss of spawning and nursery grounds Pollution – results in lower HSC reproduction and survival rates Harvest - HSCs are over-harvested as food source, their eggs are especially popular.

Is this species considered endangered? What conservation efforts are currently underway to protect or preserve this species?	*T. tridentatus* is protected as a national treasure in Japan and the Japanese are worried about regional (localized) extinction. In Hong Kong, HSCs can only be found on particular beaches in Deep Bay and Lantau Island, and are no longer found on other beaches where they had been observed in the past. People are being educated about HSHs and actively encouraged to no longer eat HSCs. Female HSCs are particularly vulnerable, as they are prized for their eggs (as food for humans). In China, a Marine Conservation Areas for Rare and Endangered Species has been created for the *T. tridentatus* population that breeds at Pingtan Island, Fujian Province. In Japan, The Kasaoka Municipal Horseshoe Crab Museum (built in 1990) is focused on awareness, education and conservation of *T. tridentatus*. The museum has an active HSC rearing program along with research involving the use of radio telemetry to follow migration patterns, locate overwintering grounds and spawning beaches.
Is there any current research involving the species?	Researchers continue to discover new compounds in HSC blood (in addition to LAL) that have potential medical uses. Research into use of HSC blood components is ongoing. One compound (peptide) called T140 is being investigated as a possible way to inhibit the infection of human cells by HIV. T140 may also be useful in protection against the spread of several types of cancer (including breast and prostate cancer and leukemia) and as a potential rheumatoid arthritis treatment.
Interesting stories/legends/fun facts:	Will vary according to what students find interesting. Some possibilities include: DNA and protein electrophoresis have been used to ID the three species. According to one source, the Japanese HSCs mate for life! It is estimated that the current population of *T. tridentatus* in Japan is only 2000-4000 HSCs The Nintendo Pokemon character Kabuto was inspired by HSCs

HSCs Around The World – Web Research Answer Key *Tachypleus gigas*

Species (Latin) name:	*Tachypleus gigas*
Common name(s):	Coastal HSC Pacific Horseshoe Crab Asian Horseshoe Crab Indian Crab
Classification - kingdom through species:	Kingdom: Animalia; Phylum: Arthropoda; Class: Merostomata; Order: Xiphosura; Family Limulidae; Genus: Limulus; Species: *Limulus polyphemus*
Geographic distribution (Where in the world does this species live?):	*T. gigas* is found in the Indo-Pacific region from the Bay of Bengal to Indonesia, Borneo and N Australia
Unique anatomical and behavioral features (as compared to other species of HSCs):	Shell is greyish The telson (tail) is serrated and triangular in cross-section.
Size range - males and females (How large do they get?):	Maximum recorded total length of *T. gigas* is 50cm. Average length: 35cm. Diameter of prosoma at its widest point ranges to about 25cm. Generally considered to be the smallest of the three Asian species.
Does this species coexist with any other HSCs species? If so, which one(s)?	All three Asian species co-exist in the waters surrounding Hong Kong. Found in Singapore along with *Carcinoscorpius rotundicula*
Nesting habitat:	Sandy estuarine and creek areas.
How is this species used by humans?	There is very little direct use of this species by humans, other than for scientific research.

Threats to survival/ impacts on this species (e.g. climate change, shoreline development, etc.)	The most serious impact is the degradation and destruction of breeding beaches by excess human activities. The Singapore Red Data Book states the following: "In the last two decades, many good natural shorelines have been developed or 'improved' through a variety of 'beach improvement' schemes, reclamation and other developments, so much so that the Coastal horseshoe crab has become less common and the species should be regarded as endangered in the Singapore context." There is no known commercial exploitation for the production of amebocyte lysate (TAL) or bait for other fisheries.
Is this species considered endangered? What conservation efforts are currently underway to protect or preserve this species?	*T. gigas* is listed as 'Endangered' on the Red List of threatened animals of Singapore. It is mainly threatened by habitat loss. In 2005 the Indian ministry of science and technology is planning to ask environment and forest minister A Raja to declare *T.gigas* an endangered species.
Is there any current research involving the species?	Japanese researchers are investigating the properties of tachyplesins, compounds that are found in HSC blood that have bactericidal properties (i.e. destroy bacteria). New tachypleasins have been discovered in the blood of *T. gigas*.
Interesting stories/legends/fun facts:	Answers will vary, depending on what students find interesting. Some possible interesting facts include: In 2003, biologists of the prestigious National Institute of Oceanography (NIO) and the National Centre for Cell Sciences (NCCS) in India cultured the primary cells of the Indian Horseshoe Crab from a gill flap. They were able to produce amoebocytes (the defensive cells found in HSC blood).

HSCs Around The World – Web Research Answer Key *Limulus polyphemus*

Species (Latin) name:	*Limulus polyphemus*
Common name(s):	The American horseshoe crab, King crab, saucepan crab, piggyback crab, helmet crab, stinky crab
Classification - kingdom through species:	Kingdom: Animalia; Phylum: Arthropoda; Class: Merostomata; Order: Xiphosura; Family Limulidae; Genus: Limulus; Species: *Limulus polyphemus*
Geographic distribution (Where in the world does this species live?):	Atlantic Coast and Gulf of Mexico
Unique anatomical and behavioral features (as compared to other species of HSCs):	Juvenile HSCs usually spend the first two years of life on intertidal sand flats. Then they move deeper bay waters.
Size range - males and females (How large do they get?):	Mature female: 9-12" across the widest part of the prosoma and 16-20" long Mature male: 7-9" across and 13-16" in length Females are approximately 20% larger than males
Does this species coexist with any other HSCs species? If so, which one(s)?	*L. polyphemus* is the sole HSC species found in North America
Nesting habitat:	Sandy beaches usually within bays or inlets where there is protection from waves and surf. Ideal nesting locations are near intertidal sand flat areas, which provide protection from waves and food sources for juveniles.
How is this species used by humans?	Formerly ground up & used as fertilizer and food for pigs Bait for eel and conch (whelk) fisheries Chitin extracted from exoskeletons Biomedical use: LAL extracted from HSC blood is used to ensure that injectable pharmaceuticals, implants and other medical devices are free from bacterial endotoxin contamination.

Threats to survival/ impacts on this species (e.g. climate change, shoreline development, etc.)	Loss of spawning habitat due to coastal development (jetties, bulkheads, dredging and beach nourishment, etc.) Harvesting for use as bait for eel and conch fisheries Harvesting for biomedical purposes Pollution: heavy metals and oil spills affect juveniles in particular
Is this species considered endangered? What conservation efforts are currently underway to protect or preserve this species?	Although HCSs are on the endangered species list, there is definitely concern as HSC populations declined dramatically during the second half of the 20th century. Chesapeake Bay and Atlantic Coast Horseshoe Crab Fishery Management Plan: this includes spawning and tagging surveys, protection of the ecological role of HSCs, identification of spawning beaches, and use of bait bags, along with research into developing synthetic bait for eel and conch and a synthetic form of LAL In 2001, the National Marine Fisheries Service (NMFS) created the Carl Shuster Horseshoe Crab Sanctuary in the Delaware Bay where harvesting of HSCs is not allowed.
Is there any current research involving the species?	Research into the use of HSC blood components (in addition to LAL) is ongoing. One compound (peptide) called T140 is being investigated as a possible way to inhibit the infection of human cells by HIV. T140 may also be useful in protection against the spread of several different types of cancer (including breast and prostate cancer and leukemia) and as a potential treatment of rheumatoid arthritis.
Interesting stories/legends/fun facts:	Answers will vary, depending on what students find interesting. Some possible interesting facts include: HSC eggs are used as the primary food source by at least eleven species of migratory birds during their stopover in Delaware Bay. Many invertebrates and fish eat HSC eggs and larvae, as well as whelk and all species of crabs. Adult HSC are a staple in the diet of loggerhead turtles. Female HSCs may lay up to 90,000 eggs during the spawning season. It is estimated that only 10 of these eggs will survive to maturity.