CARE CONNECTING ARCTIC/ANTARCTIC RESEARCHERS & EDUCATORS

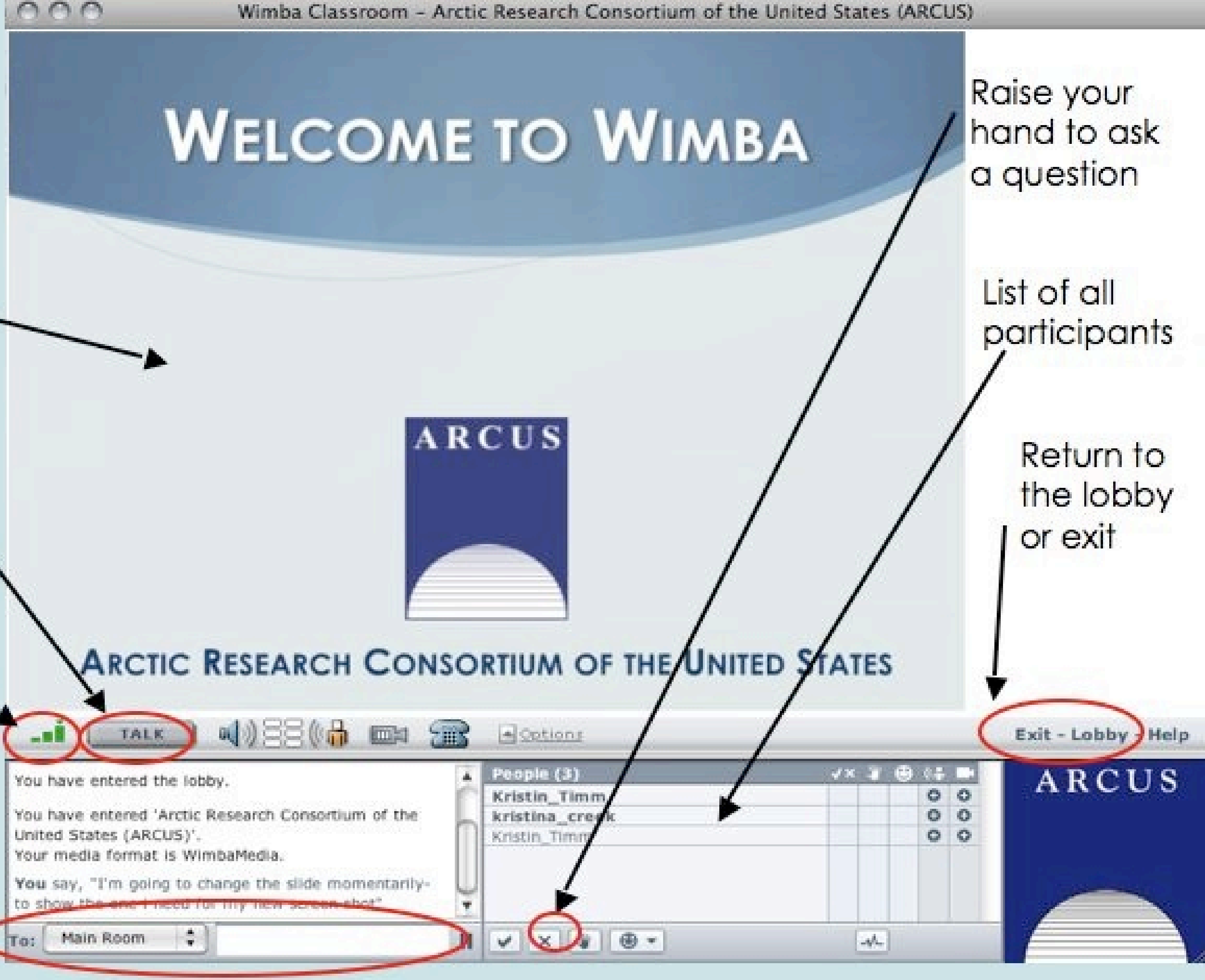
Welcome to CARE

Connecting Arctic/Antarctic
Researchers and Educators

From the Tropics to the Poles: What the Oceans Have to Tell Us About Climate Change

9 November 2009

Wimba
people teach people



Raise your hand to ask a question

Slides will be shown here

List of all participants

If using VOIP, press and hold here to talk

Return to the lobby or exit

Your connection strength

'Chat' with one person or the entire group

Please note:

- Participant using the telephone can mute/unmute by pressing *6 on the phone.
- Today's event will be recorded and archived.

What is CARE?

Connecting Arctic/Antarctic Researchers and Educators (CARE) is a professional development network managed by ARCUS, using online web meetings to support the integration of science research experiences into classroom curriculum. CARE brings together teachers and researchers to discuss field experiences, current science issues, content, technology resources, and pedagogy.

http://www.polartrec.com/care

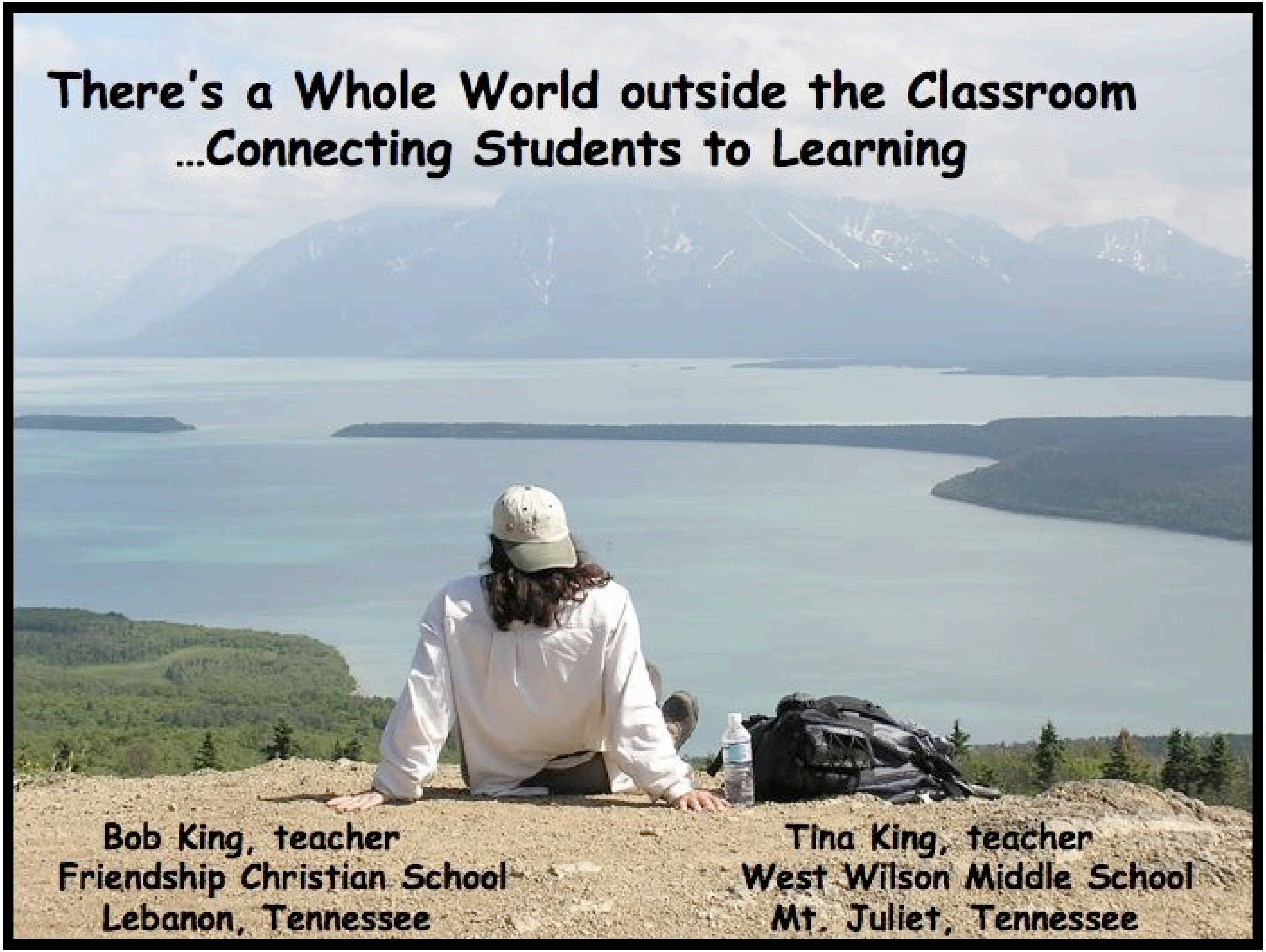
Today's Presenters

Tina King, Teacher, West Wilson Middle School, Mt. Juliet, Tennessee

Bob King, Teacher, Friendship Cristian Schools, Lebanon. Tennessee

R. Mark Leckie, Professor, University of Massachusetts, Amherst, MA

Sam Bowser, Research Scientist, Wadsworth Center, Albany, NY

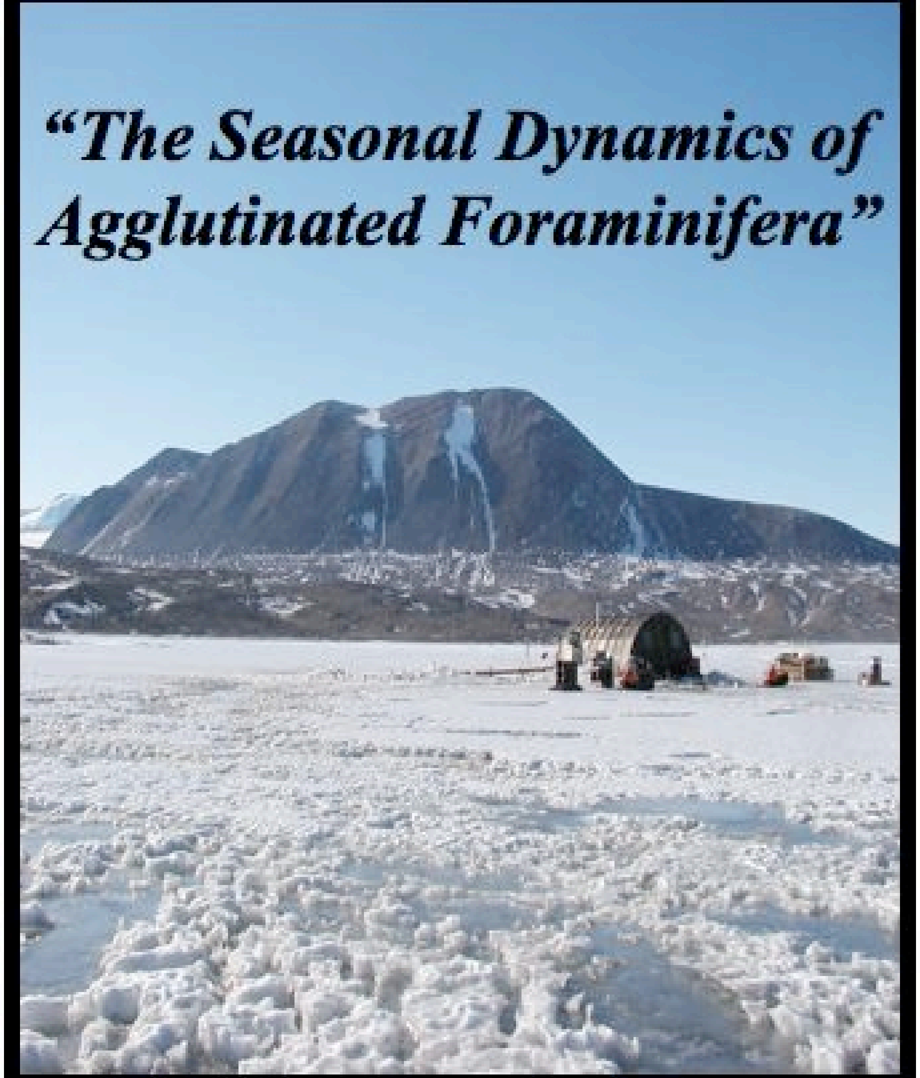

There's a Whole World outside the Classroom
...Connecting Students to Learning
Bob King, teacher
Friendship Christian School
Lebanon, Tennessee
Tina King, teacher
West Wilson Middle School
Mt. Juliet, Tennessee

Connecting Students to Scientists

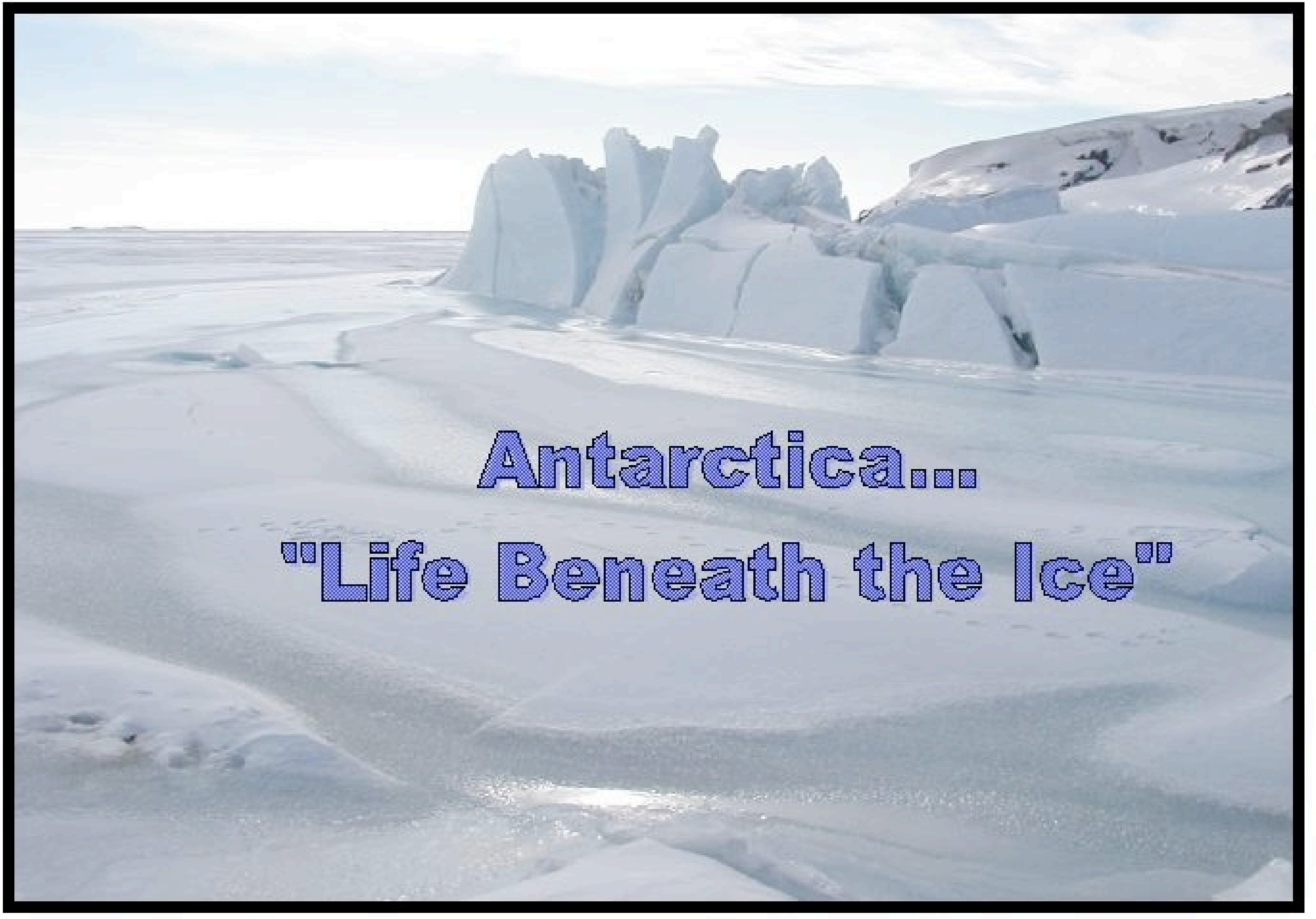
Dr. Sam Bowser, Research Scientist
Wadsworth Center, Albany, NY

National Science Foundation's Program:

"Teachers Experiencing Antarctica and the Arctic"



November 2-December 21, 2001


Antarctica...
"Life Beneath the Ice"

Marine science at the base of the Taylor Dry Valley

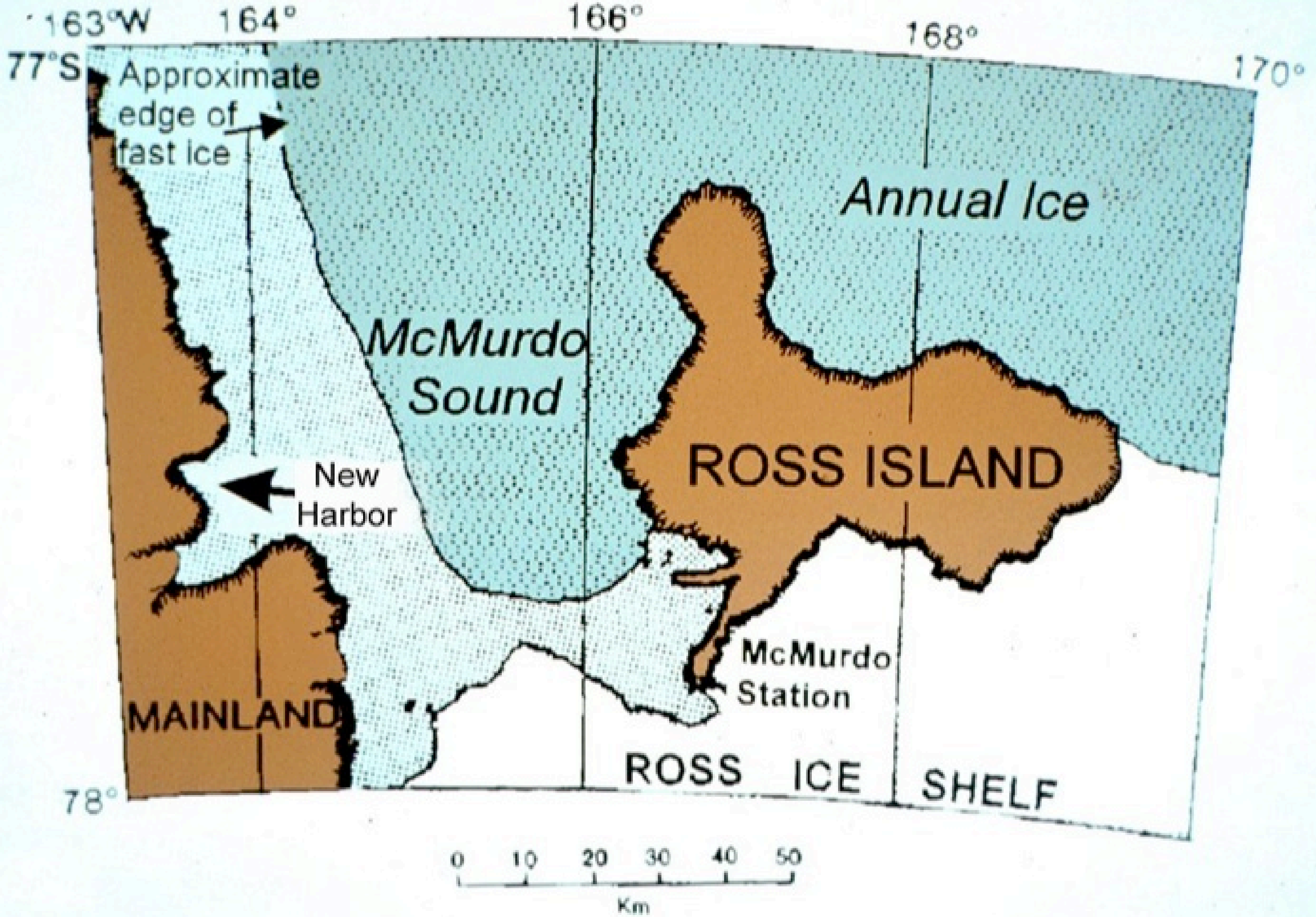
Sam Bowser, Wadsworth Center, Albany, NY
Molly Miller, Vanderbilt University, Nashville, TN
Sally Walker, University of Georgia, Athens, GA

1) Using sediment cores to study the biology of Foraminifera
2) Using cores to study the distribution of Foraminifera living in the top cm of sediment.
3) Figuring out what "sticks around" to become part of the fossil record (= a science called "taphonomy"). See this link to Dr. Sally Walker's taphonomic work:

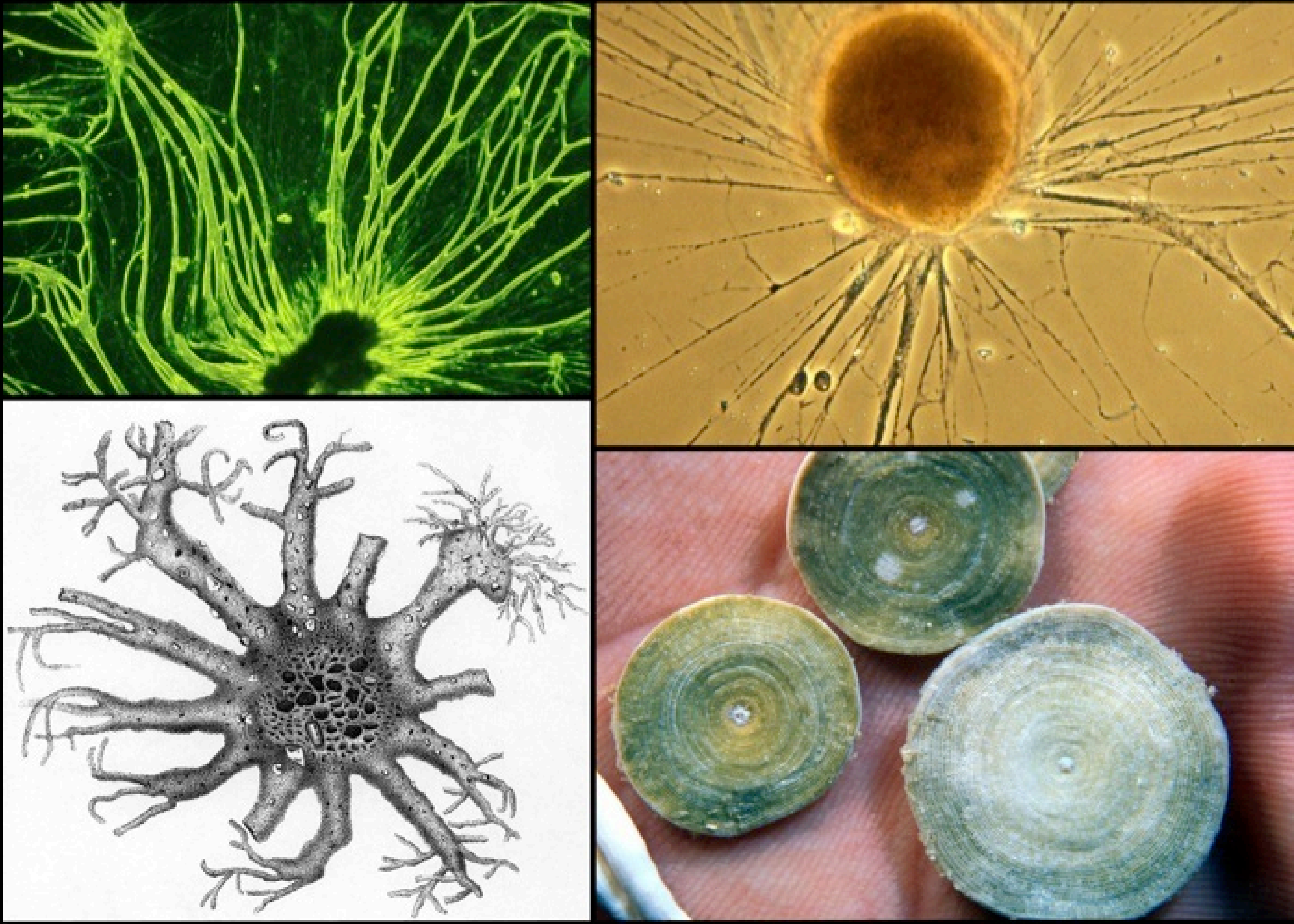
http://www.windows.ucar.edu/tour/link=/people/postcards/polarfossil/polarfossil_post.html


ANTARCTICA

EXPLORERS COVE
FIELD OPERATIONS


163°W
164°
166°
168°
170°
77°S
Approximate
edge of
fast ice
Annual Ice
McMurdo
Sound
ROSS ISLAND
New
Harbor
McMurdo
Station
MAINLAND
ROSS ICE SHELF
78°
0 10 20 30 40 50
Km

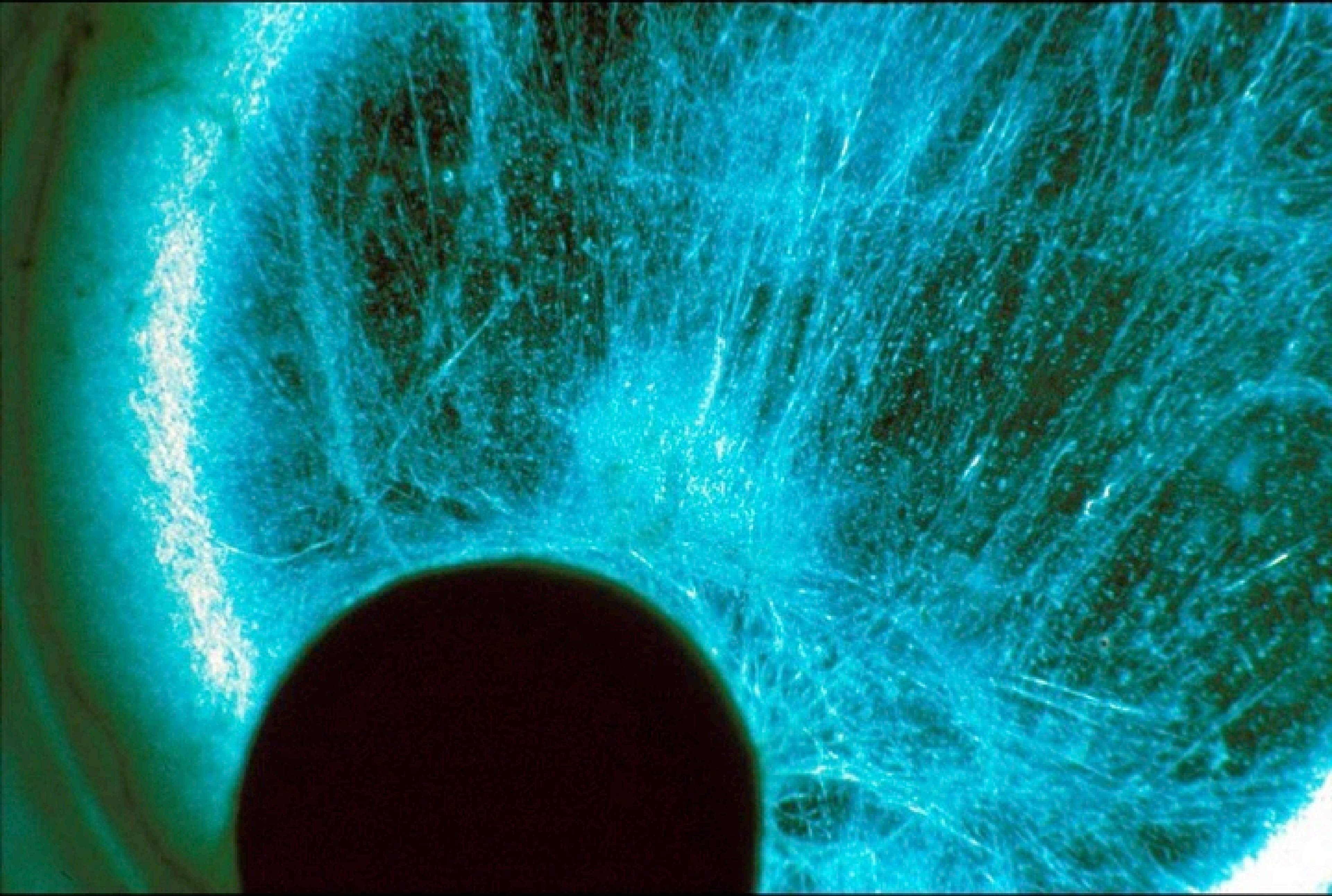
What are Foraminifera?



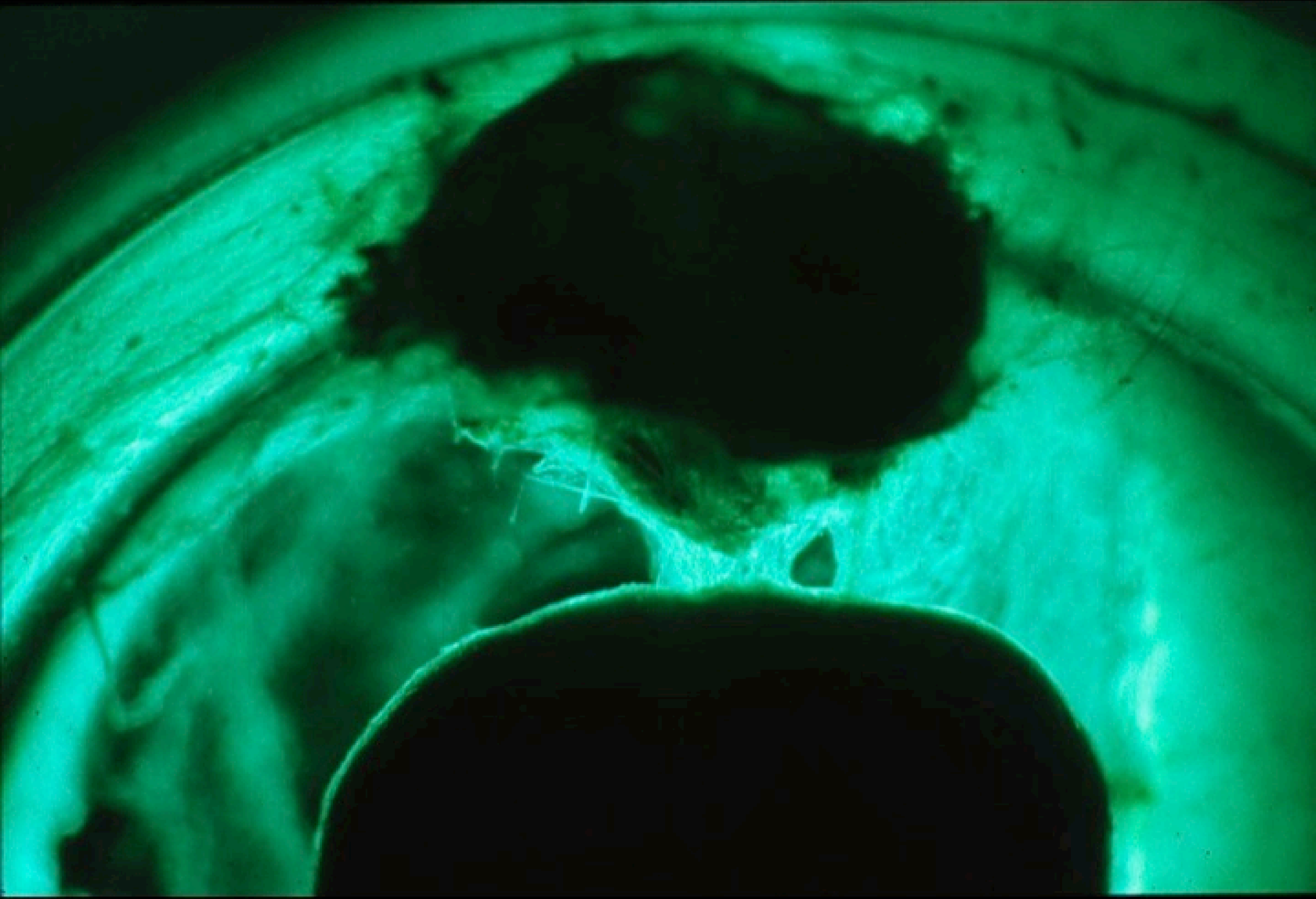

DUI

QUESTIONS ABOUT THE BIOLOGY OF GIANT FORAMS:

- WHAT DO THEY EAT?
- WHERE ARE THEY FOUND?

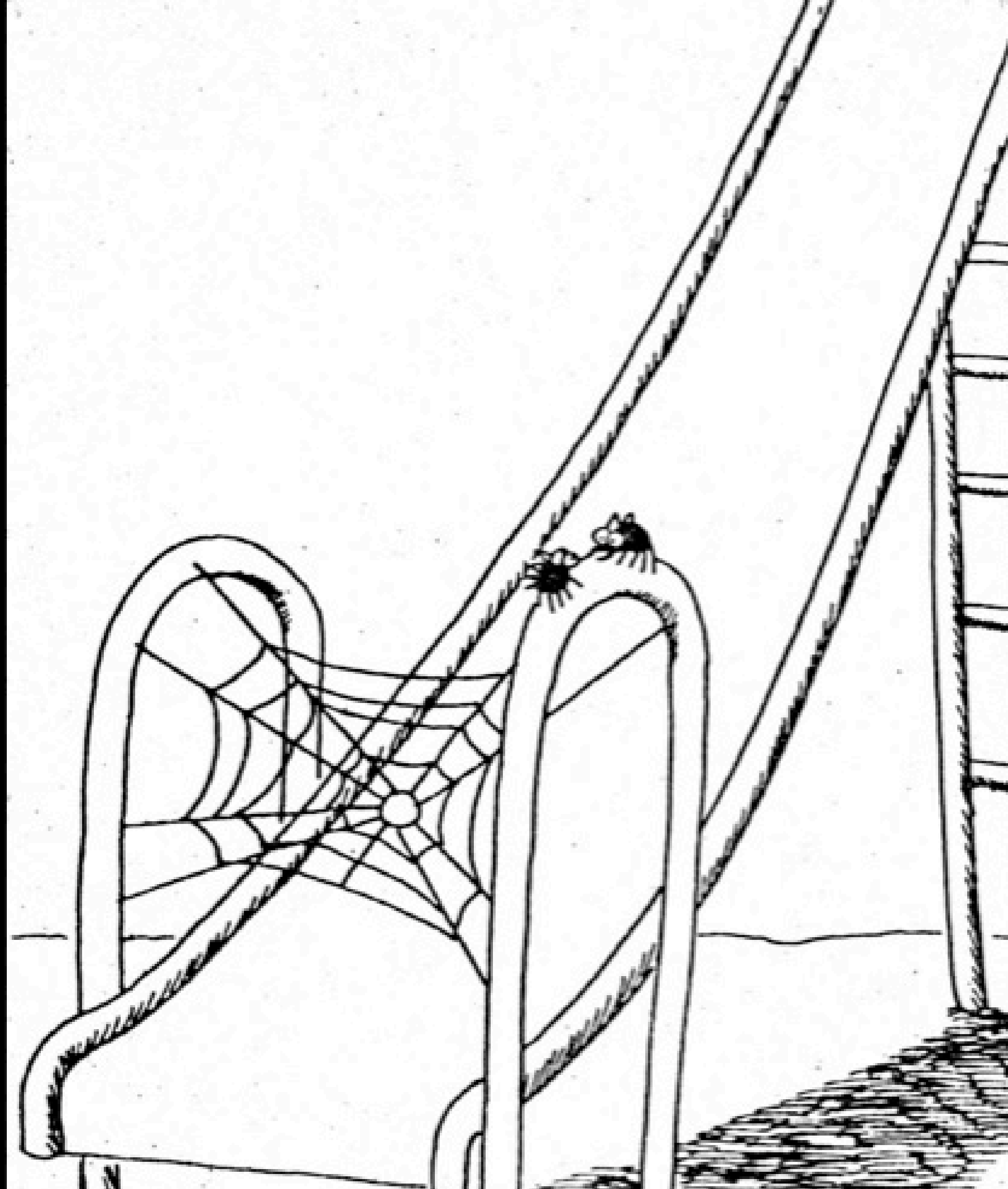



200µm



FORAMINIFERA ARE CARNIVORES!

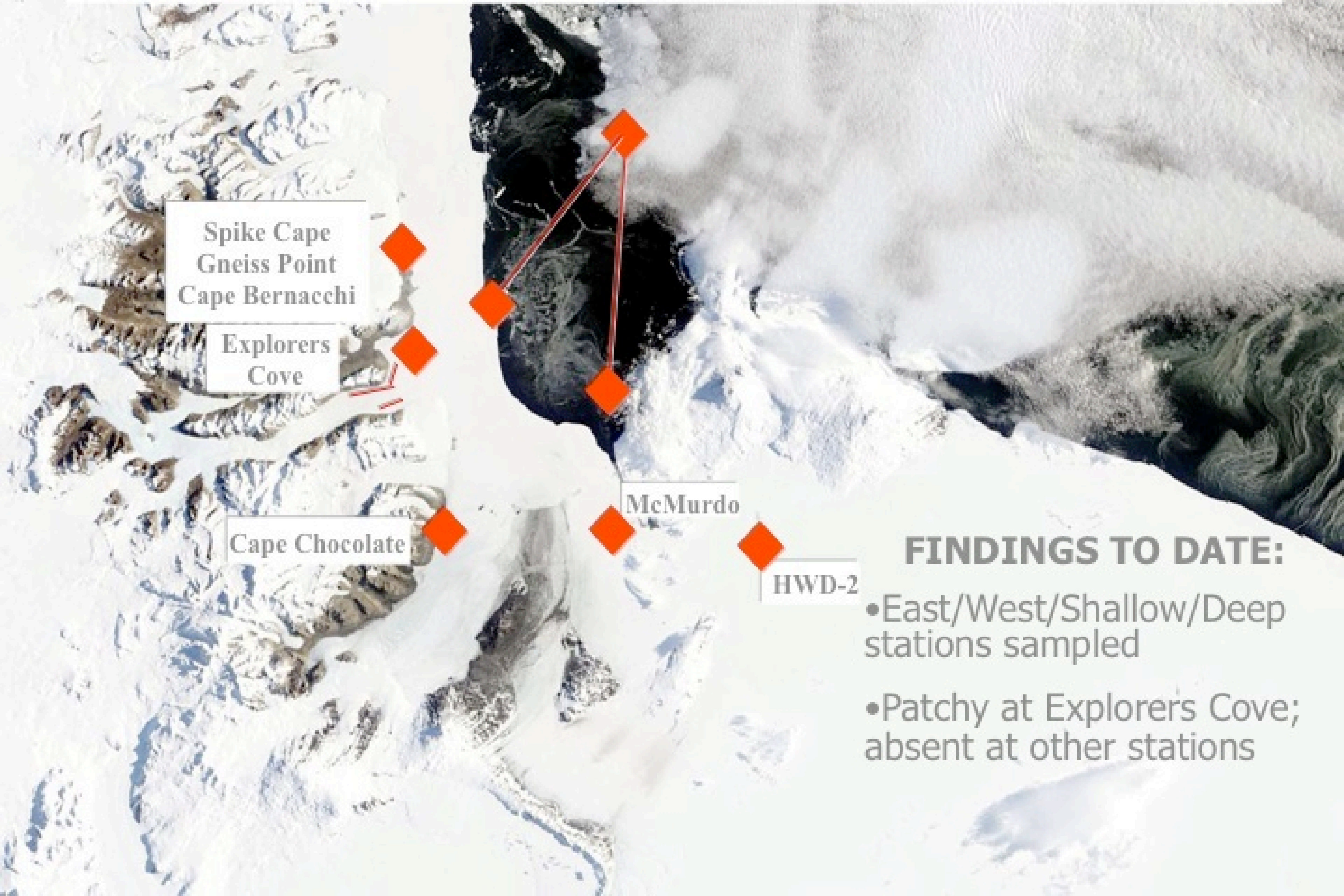
(actually omnivores, but whatever…)



"If we pull this off, we'll eat like kings."

CAN A SINGLE-CELL CREATURE BE AN ENDANGERED SPECIES???

Notodendrodes distribution: McMurdo Sound



FINDINGS TO DATE:

- East/West/Shallow/Deep stations sampled
- Patchy at Explorers Cove; absent at other stations

Special thanks to:
Sarah Broderick
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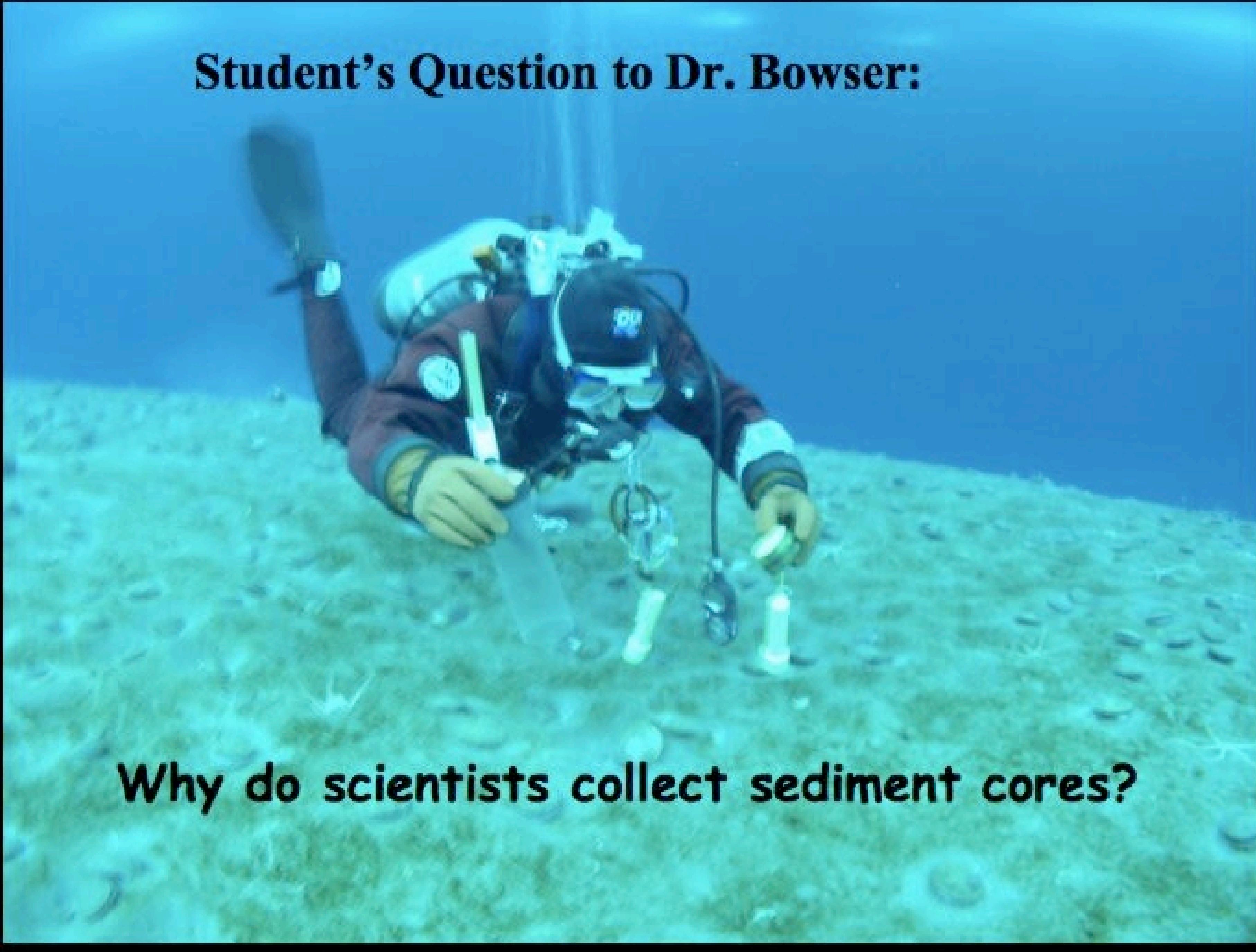
Dr. Jack Harris
Dr. Sergei Korsun
Dr. Andrew Gooday
Dr. Tomas Cedhagen
Dr. Jan Pawlowski
Dr. Steve Alexander
Dr. Steve Hanes
Dr. Sue Goldstein
Dr. Jeff Travis
Dr. Jere Lipps
Dr. Ted DeLaca
Divers: N Pollock, D Coons, R Sanders, L Haywood, K Sterling, S Harper G Gwardschaladse, J Tyson, P Forte, H Kaiser, S Clabuesch, C Shin
Antarctic support (USA): NY Air Natl Guard, US Coast Guard (Polar Star), RPSC, PHI, National Science Foundation (ANT-0440769 & ANT-0739583)

The end


Student's Question to Dr. Bowser:
Why do scientists collect sediment cores?

Homepage About the Project For Teachers For Students

The Skittle Core Lab

The Skittle Core Lab brings quantitative ecology into the classroom environment. Students are introduced to Dr. Sam Bowser's Antarctic research program, and to the organisms (called "foraminiferans") that he studies. Then, students re-create his coring experiments using Skittles to represent the forams.

Real-World Sampling

All about the field work. Information about Foraminifera, and a photo gallery of the Bowser Lab collecting foraminiferans under the ice at Explorers Cove, McMurdo Sound, Antarctica.

Teaching the Lab

Lab sheets and lesson plans for several grade levels, plus extended extercises, sources for materials, sample data, and a photo gallery of students doing the lab.

This project was supported by NSF grant ANT0440769

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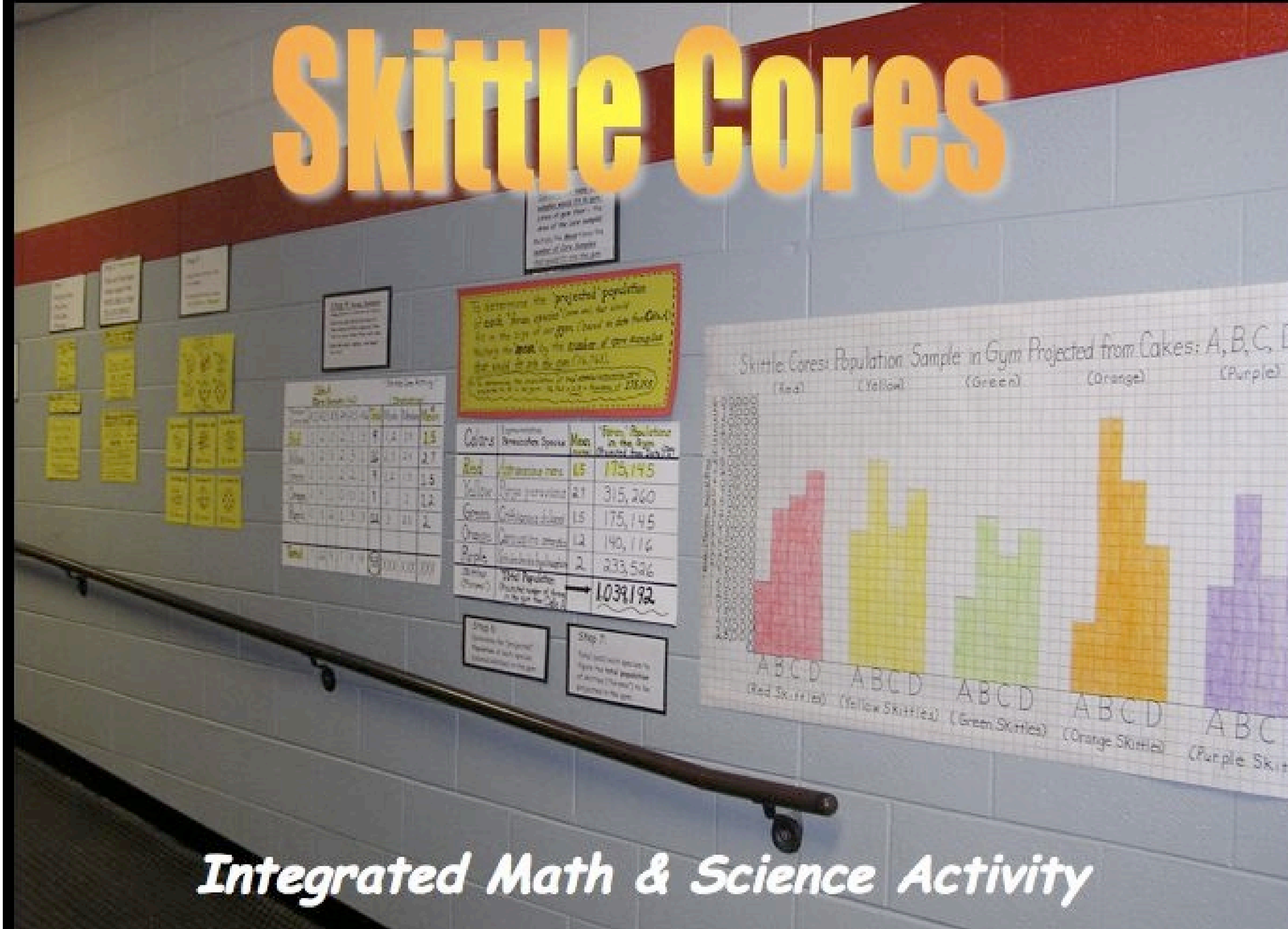

Skittle Cores
Skittle Cores: Population Sample in Gym Projected from Cakes: A, B, C, D
(Red)
(Yellow)
(Green)
(Orange)
(Purple)
A B C D
(Red Skittles)
(Yellow Skittles)
(Green Skittles)
(Orange Skittles)
Colors
Red
Yellow
Green
Orange
Purple
175,145
315,260
175,145
140,116
233,526
1,039,192
Integrated Math & Science Activity

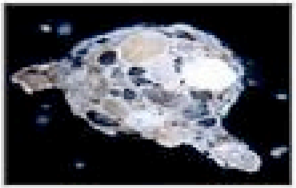
Meet the forams

Now that you have figured out the distribution of your forams in the core sample, here's what they look like. You can print out this guide.

Mrs. King studied these forams in Antarctica. Here are her notes. You can also learn more about forams on the Web.

Astrammina rara

- One of the most common forams in Explorers Cove
- Reticulopodia are very strong: they can even catch baby shrimp
- The cell has one very large nucleus: you can see it without a microscope



Ready to learn more?

A closeup of *Astrammina* in its native habitat
More pictures of *Astrammina*

Pyrgo peruviana

- *Pyrgo* are normally found in deep water: they can live in Explorers Cove because the water is very dark and cold
- Unlike the other forams, it has many chambers in its shell. It adds them one at a time, first on one side, then on the other. This picture shows the newest and biggest chamber on the bottom, and the second newest is on the top
- The shell is made out of calcium carbonate, like a clam shell, and is very hard

Ready to learn more?

Photos of live *Pyrgo*. Notice the brown stuff around the "aperture" (where the reticulopods come out of the shell); they are eating.

Crithionina delacai

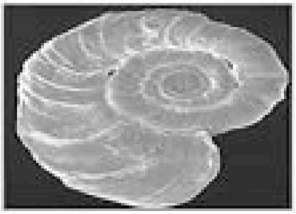
- The cell body (which is white) is very gooey, and will explode if it touches the water surface (because its "surface tension" is lower than the water's). Other forams, like *Astrammina*, can survive being taken out of the water for a short time
- The shell isn't glued together, like it is in *Astrammina* and *Notodendrodes*; instead, the foram holds the sand grains together with its reticulopodia
- This foram is named after Dr. Ted DeLaca, an Antarctic scientist

Ready to learn more?

A *Crithionina* living on top of another foram

Cornuspira antarctica

- This foram also has a hard, calcium carbonate shell, but it has only two chambers: a very small one in the center, and the long coiled one
- This foram can get very large: some of the older ones in Explorers Cove are half an inch (1 cm.) across
- Forams like this are found all over the world



Ready to learn more?

Cornuspira and relatives from the tropics
A closeup of the wall of the shell. The little calcium carbonate rods are randomly oriented, which makes the foram look shiny and white, like porcelain. (*Pyrgo*'s shell looks like this too.)

Notodendrodes hyalinosphaira

Facts about *Notodendrodes hyalinosphaira*:

- This species can be found either as a simple sphere or in the tree form shown in the picture
- We think the tree helps the foram lift up its reticulopodia, so it can catch floating food
- "Hyalinosphaira" means "glassy ball"; it is named that because it often makes its shell out of clear quartz crystals

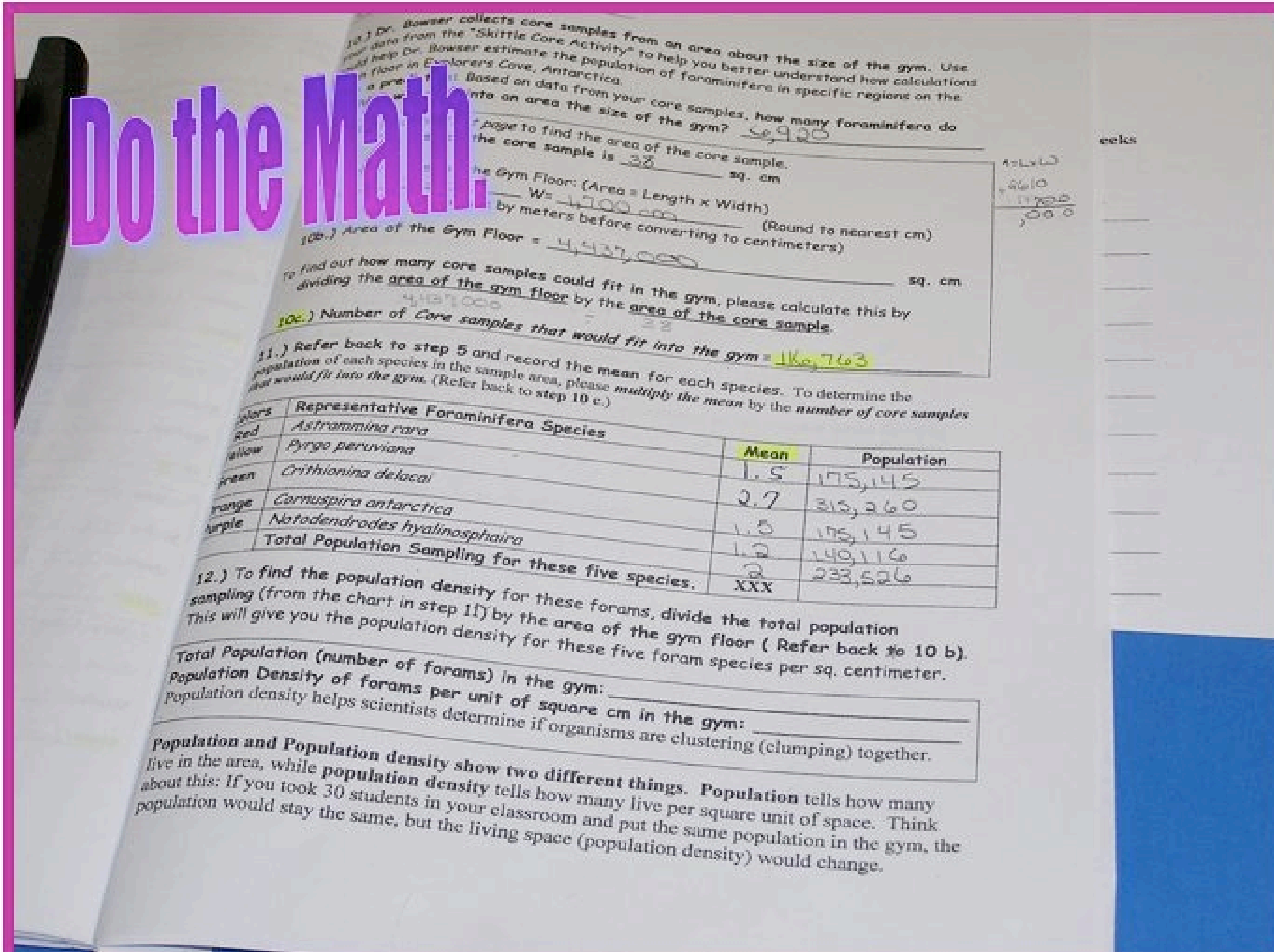
Ready to learn more?

A closeup of *Notodendrodes* in its native habitat
More about tree forams

9 x 13" cake pan with Skittle-laden Brownies

Skittle Core Tools

Core Samples



Do the Math.

10.) Dr. Bowser collects core samples from an area about the size of the gym. Use your data from the "Skittle Core Activity" to help you better understand how calculations could help Dr. Bowser estimate the population of foraminifera in specific regions on the ocean floor in Explorers Cove, Antarctica.

a prediction: Based on data from your core samples, how many foraminifera do ... into an area the size of the gym? 56,920

... page to find the area of the core sample.

... the core sample is 38 sq. cm

... the Gym Floor: (Area = Length x Width)

W= 4,700 cm

... by meters before converting to centimeters) (Round to nearest cm)

10b.) Area of the Gym Floor = 4,437,000 sq. cm

To find out how many core samples could fit in the gym, please calculate this by dividing the **area of the gym floor** by the **area of the core sample**.

10c.) Number of Core samples that would fit into the gym = 116,763

11.) Refer back to step 5 and record the mean for each species. To determine the population of each species in the sample area, please *multiply the mean* by the *number of core samples that would fit into the gym.* (Refer back to step 10 c.)

Colors	Representative Foraminifera Species	Mean	Population
Red	*Astrammina rara*	1.5	175,145
Yellow	*Pyrgo peruviana*	2.7	315,260
Green	*Crithionina delacai*	1.5	175,145
Orange	*Cornuspira antarctica*	1.2	140,116
Purple	*Notodendrodes hyalinosphaira*	2	233,526
	Total Population Sampling for these five species.	XXX	

12.) To find the population density for these forams, divide the total population sampling (from the chart in step 11) by the area of the gym floor (Refer back to 10 b). This will give you the population density for these five foram species per sq. centimeter.

Total Population (number of forams) in the gym: ____

Population Density of forams per unit of square cm in the gym: ____

Population density helps scientists determine if organisms are clustering (clumping) together.

Population and Population density show two different things. Population tells how many live in the area, while **population density** tells how many live per square unit of space. Think about this: If you took 30 students in your classroom and put the same population in the gym, the population would stay the same, but the living space (population density) would change.

Name: ______________________________
Date: ______________________________

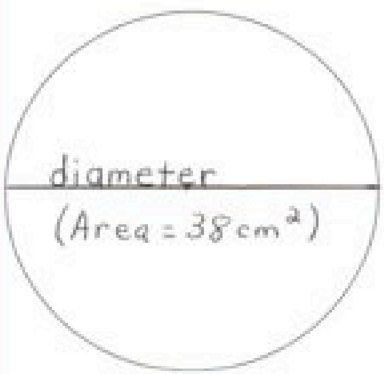
Lab Sheet A
Population Sampling

Calculating the Population Density

Introduction: *Dr. Bowser's team dives beneath the ice in Antarctica to study foraminifera. Scientists are interested in the* ***population****, or the number of organisms of the same species that live in the area. They also try to calculate the* ***population density****, or the number of individual organisms that share the same living space. Since Dr. Bowser can't count each foraminifera that lives in specific areas near Explorers Cove, he must rely on a method called* ***population sampling*** *to estimate the number of foraminifera in the area. Dr. Bowser takes several core samples from the bottom of the ocean in an area about the size of our gym. The core sample has an opening about the size of an orange juice can. This skittle core lab will give you an idea of what Dr. Bowser does in Antarctica, and why core samples are important for his research. The different colored skittles represent different species of foraminifera.*

1.) Finding the Area of the Core Sample:

A. Draw the **diameter** across the center of the orange juice can (below) and **record the diameter** and **the radius** to the nearest centimeter on the lines provided. This is the size of the **core sample**.



B. Diameter: 7 cm Radius: 3.5 cm
(radius= half the diameter)

C. What is **the formula** to find the **area** of a circle? Area = πr^2
$Pi = 3.14$

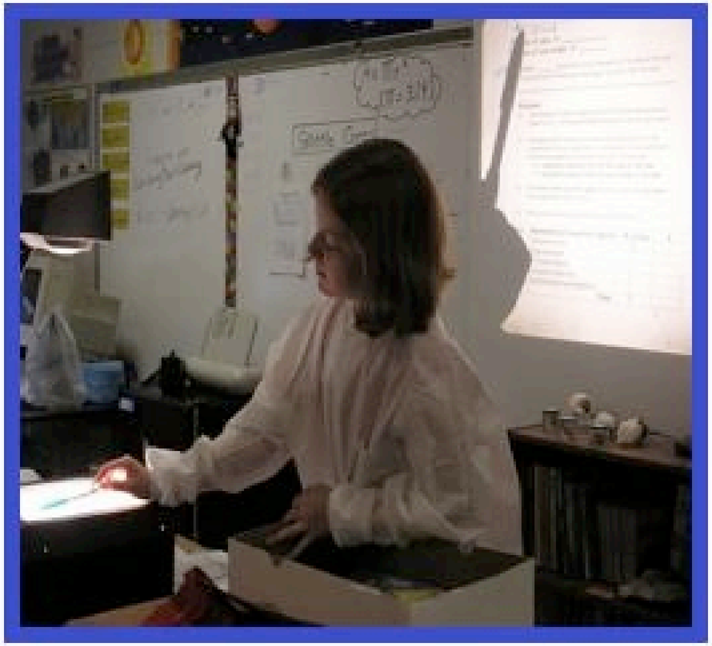
D. Find the area for this circle (**core sample**)

A= $3.14 \times (3.5 \times 3.5)$
A= 38 sq. cm

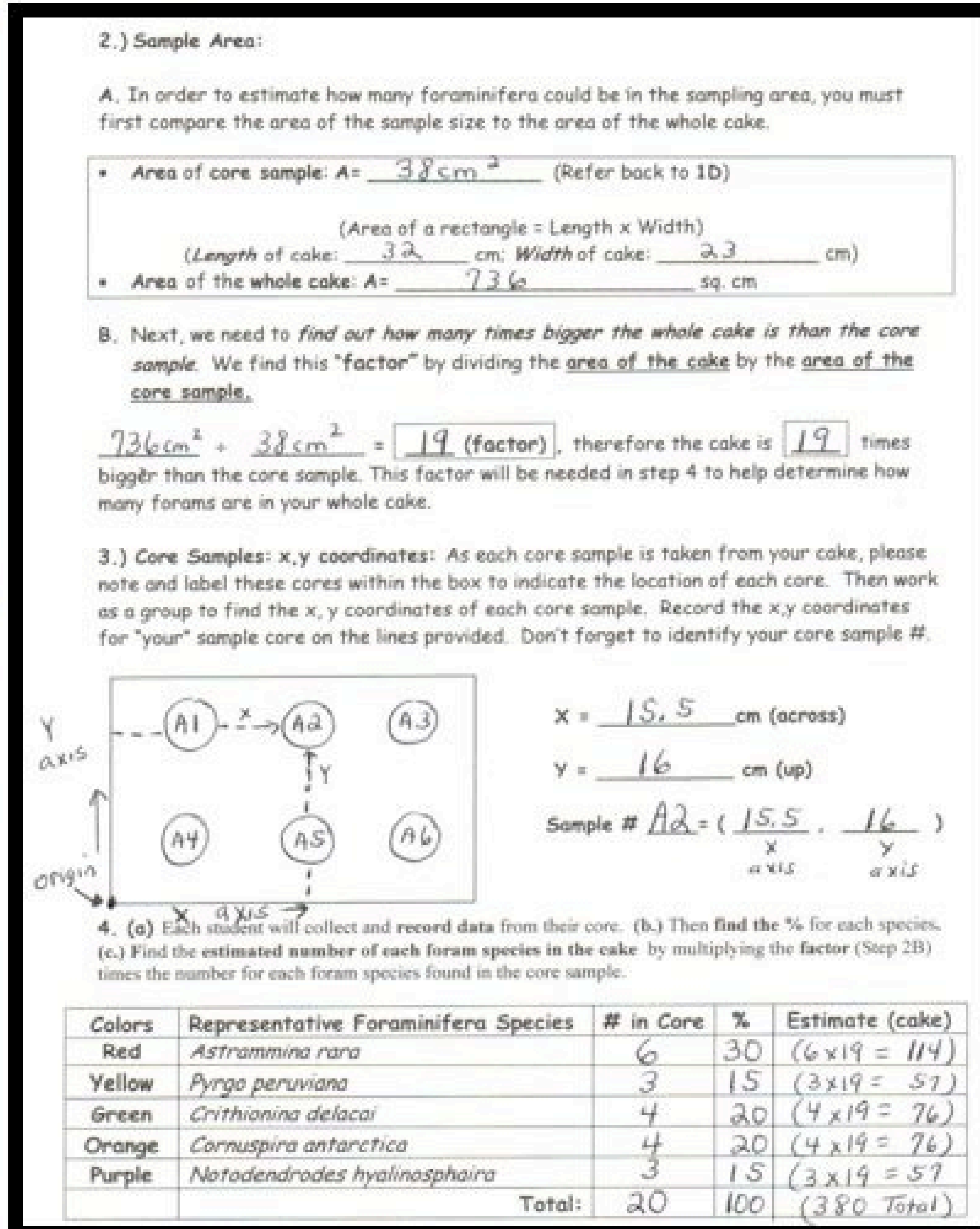
$12.25 \times 3.14 = 38.465$

Why do you think it is important for Dr. Bowser to know how many foraminifera live in an area? They need to know how the ecosystem is doing. Do the forams have enough food, or is the population going up or do? If the forams die some other animals will die, too.

Area of the Core Sample



Measuring x,y coordinates



2.) Sample Area:

A. In order to estimate how many foraminifera could be in the sampling area, you must first compare the area of the sample size to the area of the whole cake.

- **Area of core sample: A=** 38cm² (Refer back to 1D)

(Area of a rectangle = Length x Width)
(*Length* of cake: 32 cm; *Width* of cake: 23 cm)

- **Area of the whole cake: A=** 736 sq. cm

B. Next, we need to ***find out how many times bigger the whole cake is than the core sample.*** We find this **"factor"** by dividing the **area of the cake** by the **area of the core sample.**

736cm² ÷ 38cm² = 19 (factor), therefore the cake is 19 times bigger than the core sample. This factor will be needed in step 4 to help determine how many forams are in your whole cake.

3.) ***Core Samples: x,y coordinates:*** *As each core sample is taken from your cake, please note and label these cores within the box to indicate the location of each core. Then work as a group to find the x, y coordinates of each core sample. Record the x,y coordinates for "your" sample core on the lines provided. Don't forget to identify your core sample #.*

X = 15.5 cm (across)

Y = 16 cm (up)

Sample # A2 = (15.5 , 16)
x axis, y axis

4. (a) Each student will collect and **record data** from their core. (b.) Then **find the %** for each species. (c.) Find the **estimated number of each foram species in the cake** by multiplying the **factor** (Step 2B) times the number for each foram species found in the core sample.

Colors	Representative Foraminifera Species	# in Core	%	Estimate (cake)
Red	*Astrammina rara*	6	30	(6x19 = 114)
Yellow	*Pyrgo peruviana*	3	15	(3x19 = 57)
Green	*Crithionina delacai*	4	20	(4x19 = 76)
Orange	*Cornuspira antarctica*	4	20	(4x19 = 76)
Purple	*Notodendrodes hyalinosphaira*	3	15	(3x19 = 57)
	Total:	20	100	(380 Total)

Statistics: Mean, Median, and Mode

Summary: Work as a team and ... six core samples in your cake.

5.) **Using Statistics to Understand the Science**: Record the number of "forams" found in each core sample in your cake to find the total number of "forams" in your area (whole cake). Then calculate the **mode, median, and mean** for each.

	(Core Samples: 1-6)							(Statistics)		
Foram Species	A 1	A 2	A 3	A 4	A 5	A 6	Total	Mode	Median	Mean
Red	8	6	4	2	7	4	31	4	5	5.2
Yellow	4	3	6	8	3	2	26	3	3.5	4.3
Green	5	4	3	11	2	7	32	none	4.5	5.3
Orange	1	4	4	7	9	3	28	4	4	4.7
Purple	6	3	3	0	5	3	20	3	3	3.3
Total	24	20	20	28	26	19	137	XXX	XXX	XXX

6.) Using this data, find the average (mean) number of "foram" specimens per core. Use the chart above, and then divide the "Total" specimens per cake by number of cores.
137 ÷ 6 = Average # 23 per core
(22.8)

7.) Why do you think it is important for scientists to take more than one core sample in an area? You might find things you don't see in another place.

8.) What are the limiting factors (biotic or abiotic) that could affect the foraminifera in Explorers Cove, Antarctica?

Abiotic factors: (not living)

- Temperature
- oxygen
- soil/sand/rocks
- light (sun)
- ice (Icebergs "scouring")
- water (salty or fresh water)
- pollution

Biotic factors: (Living)

- fish and other animals
- algae and other plants (blocking light)
- other organisms like protists
- humans
- bacteria and food

9.) Why do you think it is important for Dr. Bowser to take core samples from the same areas from one year to the next? It is important to see the changes in that area over different years.

Name: ______ **Finding the Mode, Median, & Mean**
Date: ______ **Step 5: Calculation Lab Sheet**

Look at the chart at Step 5 to determine how many of each species are in each core sample. Note: Mode (most often data), **median** (middle number), and **mean** (find the average). When figuring **mode** and **median,** it's helpful to first *list the numbers in order from the least to the greatest.*

1. (Row: Color "Red"), Foram Species: ***Astrammina rara***

Mode: 2, 4, 4, 6, 7, 8 = 4
Median: 2, 4, (4, 6) 7, 8 = 5
Mean: 31 ÷ 6 = (5.2)

2. (Row: Color "Yellow"), Foram Species: ***Pyrgo peruviana***

Mode: 2, 3, 3, 4, 6, 8 = 3
Median: 2, 3, (3, 4) 6, 8 = 3.5
Mean: 26 ÷ 6 = (4.3)

3. (Row: Color "Green"), Foram Species: ***Crithionina delacai***

Mode: 2, 3, 4, 5, 7, 11 = (no mode)
Median: 2, 3, (4, 5) 7, 11 = 4.5
Mean: 32 ÷ 6 = (5.3)

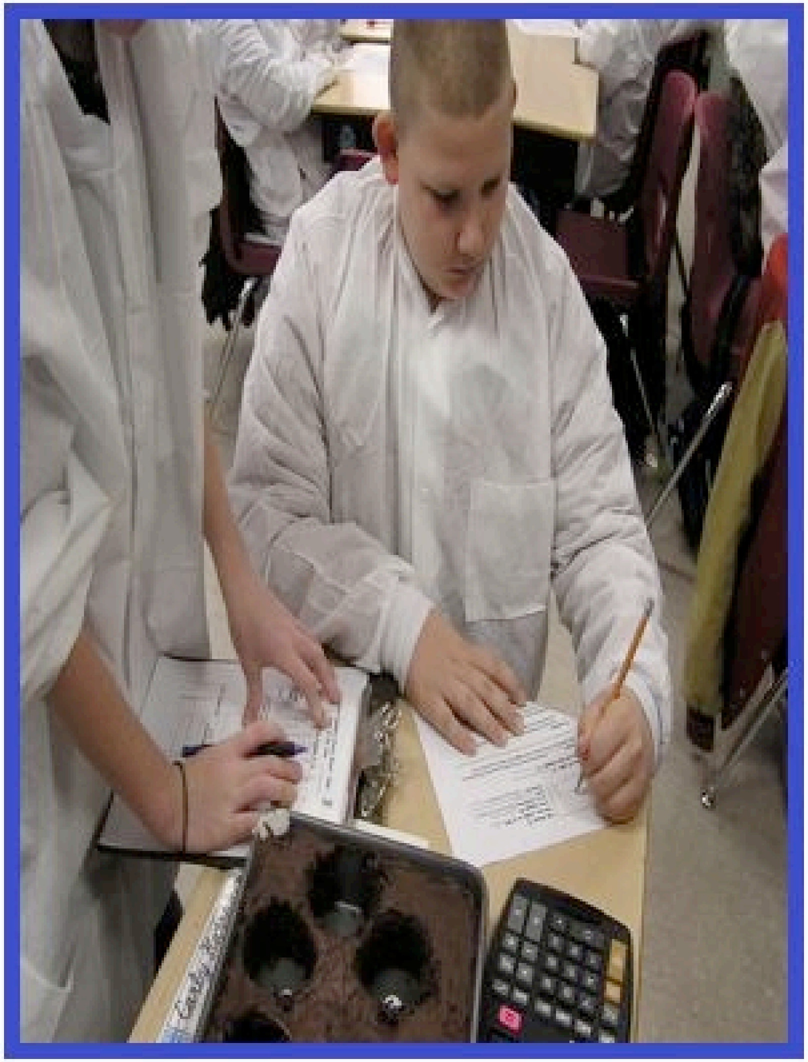
4. (Row: Color "Orange"), Foram Species: ***Cornuspira antarctica***

Mode: 1, 3, 4, 4, 7, 9 = 4
Median: 1, 3, (4, 4) 7, 9 = 4
Mean: 28 ÷ 6 = 4.7

5. (Row: Color "Purple"), Foram Species: Notodendrodes hyalinosphaira

Mode: 0, 3, 3, 3, 5, 6 = 3
Median: 0, 3, (3, 3) 5, 6 = 3
Mean: 20 ÷ 6 = 3.3 = (3.3)

Record data & Measurements



10.) **Dr. Bowser collects core samples from an area about the size of the gym.** Use your data from the "*Skittle Core Activity*" to help you better understand how calculations could help Dr. Bowser estimate the population of foraminifera in specific regions on the ocean floor in Explorers Cove, Antarctica. **Make a prediction and record on line below.**

- Based on data from your core samples, **how many foraminifera do you think would fit into an area the size of the gym?** 2,000,000

Refer back to the first page (1D) to find the area of the core sample.
10a.) The area of the core sample is 38 **sq. cm**

Next, find the area of the *Gym Floor*: (Area = Length x Width), Remember to convert meters to centimeters.
L= 2610 cm; W= 1700 cm; (Round to nearest cm)

10b.) Area of the *Gym Floor* = (4,437,000) **sq. cm**

10c.) Number of *Core samples that would fit into the gym* = 116,763 (# of core samples)
(Calculate how many core samples could fit in the gym by dividing the area of the gym floor by the area of the core sample.) *This information will be needed for step 11.*

11.) Record the "*Mean*" (Step 5) and the **"Population"** for each species on the chart below. To estimate the **population of forams** in this area, ***multiply the* mean** by the ***number of core samples that would fit into the gym*** (Refer back to 10 c)

(116,763)

Colors	Representative Foraminifera Species	Mean	Population
Red	*Astrammina rara*	5.2	607,168
Yellow	*Pyrgo peruviana*	4.3	502,081
Green	*Crithionina delacai*	5.3	618,844
Orange	*Cornuspira antarctica*	4.7	548,786
Purple	*Notodendrodes hyalinosphaira*	3.3	385,318
	Total Population Sampling for these five species.	XXX	(2,662,197)

12.) To **find the population density** for these forams, **divide the total population sampling** (from the chart in step 11) by the **area of the gym floor (Refer back to 10 b).**
The population density for these five foram species per sq. centimeter = 0.6
2,662,197 ÷ 4,437,000 = (0.59) →

sq. cm

Population density helps scientists determine if organisms are clustering (clumping) together. Record and compare the difference between the population and population density:
Total Population (number of forams) in the gym: 2,662,197
Population Density of forams per square cm in the gym: 0.6 (6/10)

Population and Population density show two different things. Population tells how many live in the area, while **population density** tells how many live per square unit of space. Think about this: If you took 30 students in your classroom and put the same population in the gym, the population would stay the same, but the living space (population density) would change.

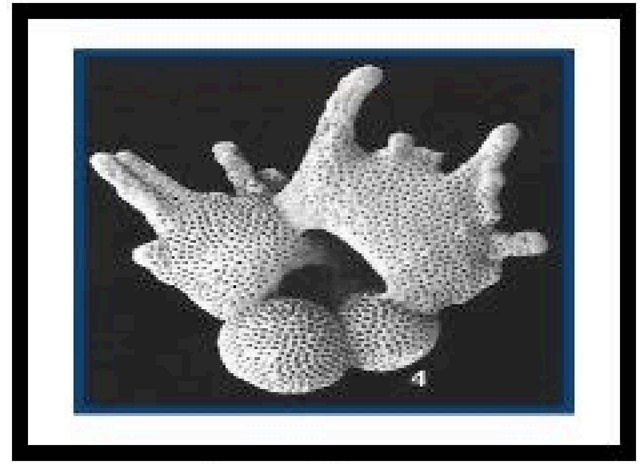
(We had 137 forams in our Cake (A).

Population vs Population Density


What
could affect the forest
Step 3:
Area of the
Gym Floor

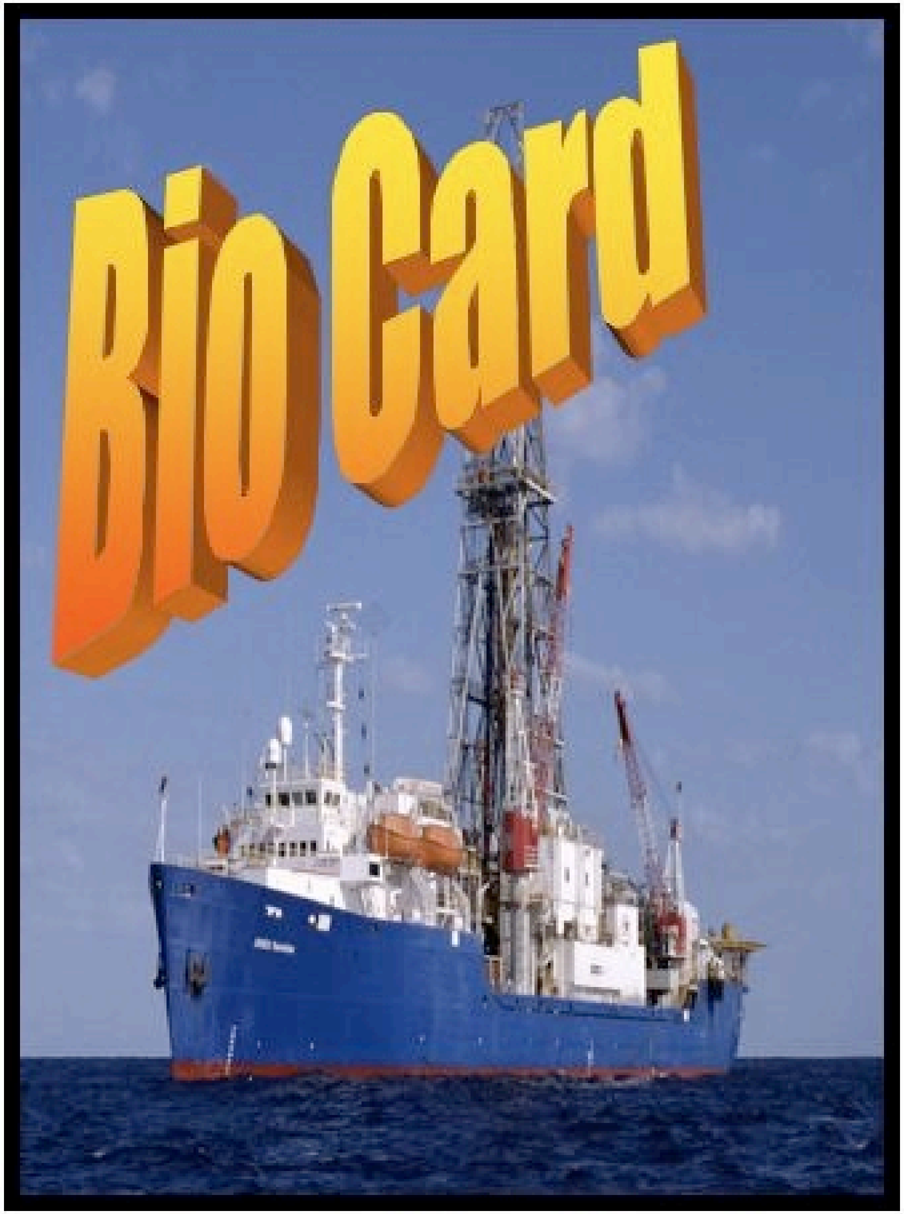
Reaching Students by Personalizing the Science

...the scientist

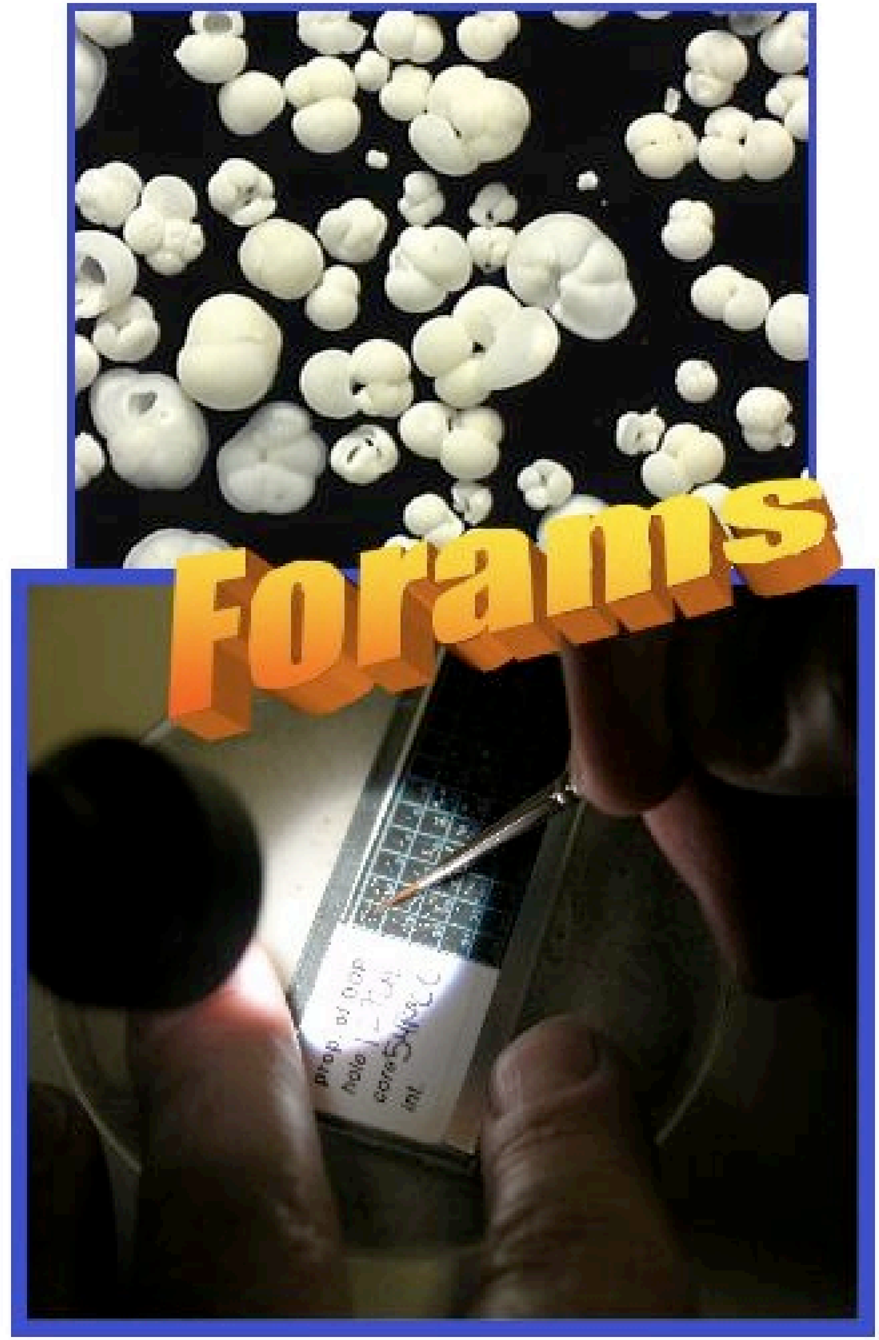


...the forams

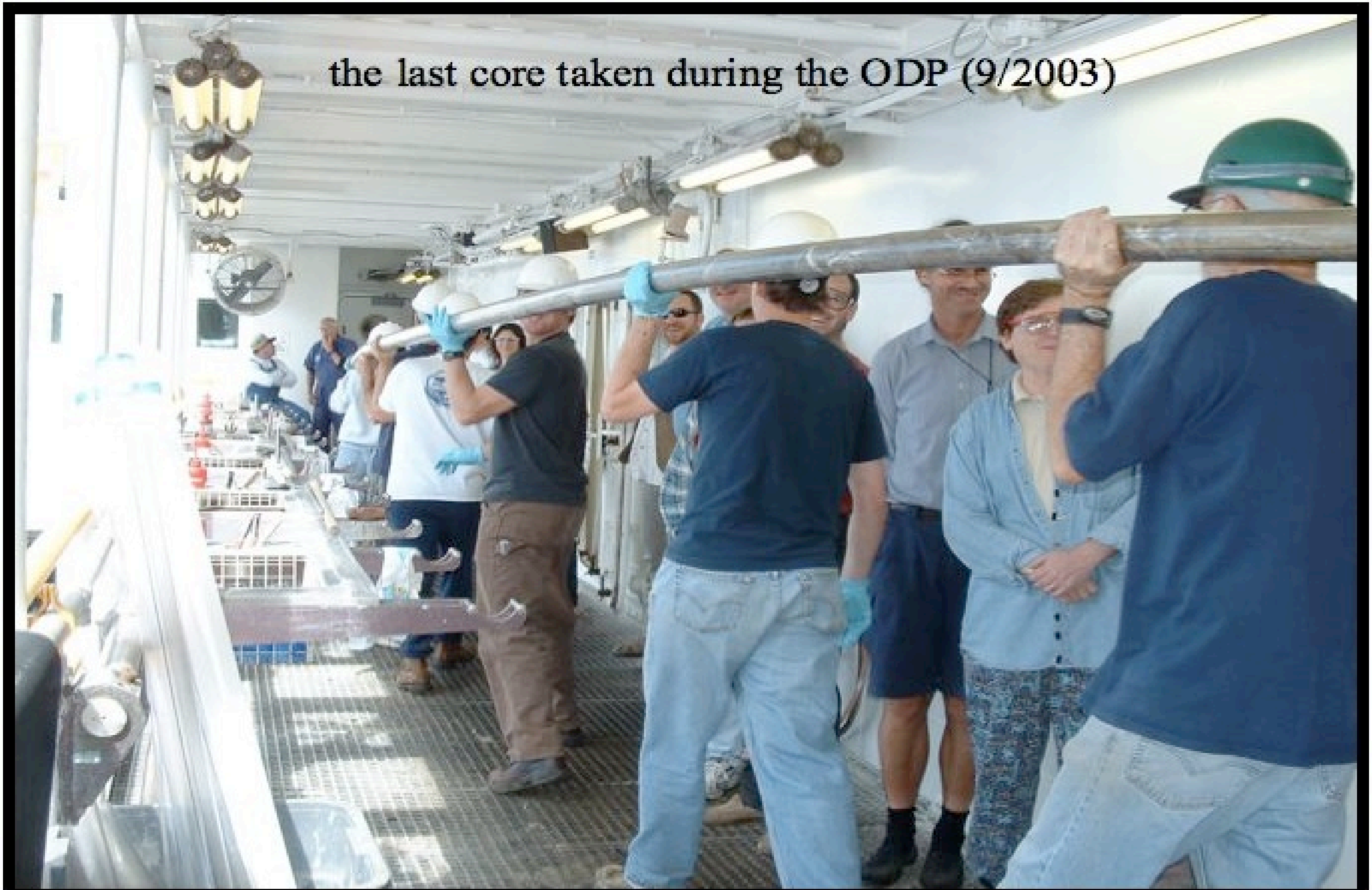
...the ship



Deep Drilling Vessel
JOIDES Resolution



How do you get research from the drilling ship into the classroom?



WANTED

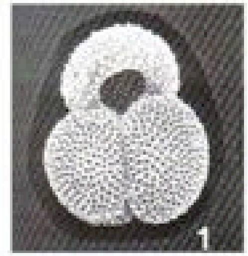
DEAD AND WELL-PRESERVED

Globorotalia fohsi
"Mohawk guy"

"***Mohawk guy***" and his band of Neogene planktic foraminifer friends, for crimes against calcareous nannofossils and other phytoplankton

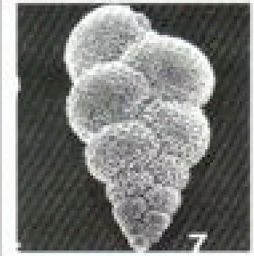
(*Last Seen at Site 806*)

Wanted Poster with Mug Shots

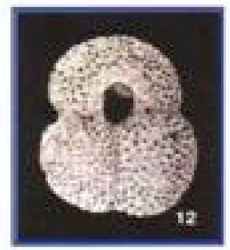


Globigerinoides ruber
"Cyclops two"

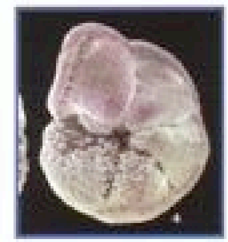
Globigerinoides sacculifer
"Sweet bubbles"



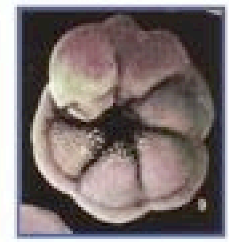
Streptochilus globigerum
"Icecream cone"



Globigerinoides subquadratus
"Cyclops one"



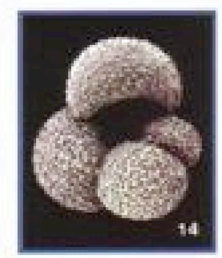
Globorotalia tumida
"The tuminator"



Globorotalia menardii
"Mini krueller"

Globigerinoides obliquus
"Top sider"

Globigerinoides fistulosus
"Bad-hair-day guy"



Globigerina bulloides
"Little bully"

Learning Objectives:

- Build a *Graphic Representation*
- Read and interpret authentic data
- Compare paleoceanographic events and the effect on biota living in the past

Target: Grades 5-12

National Science Education Standards:

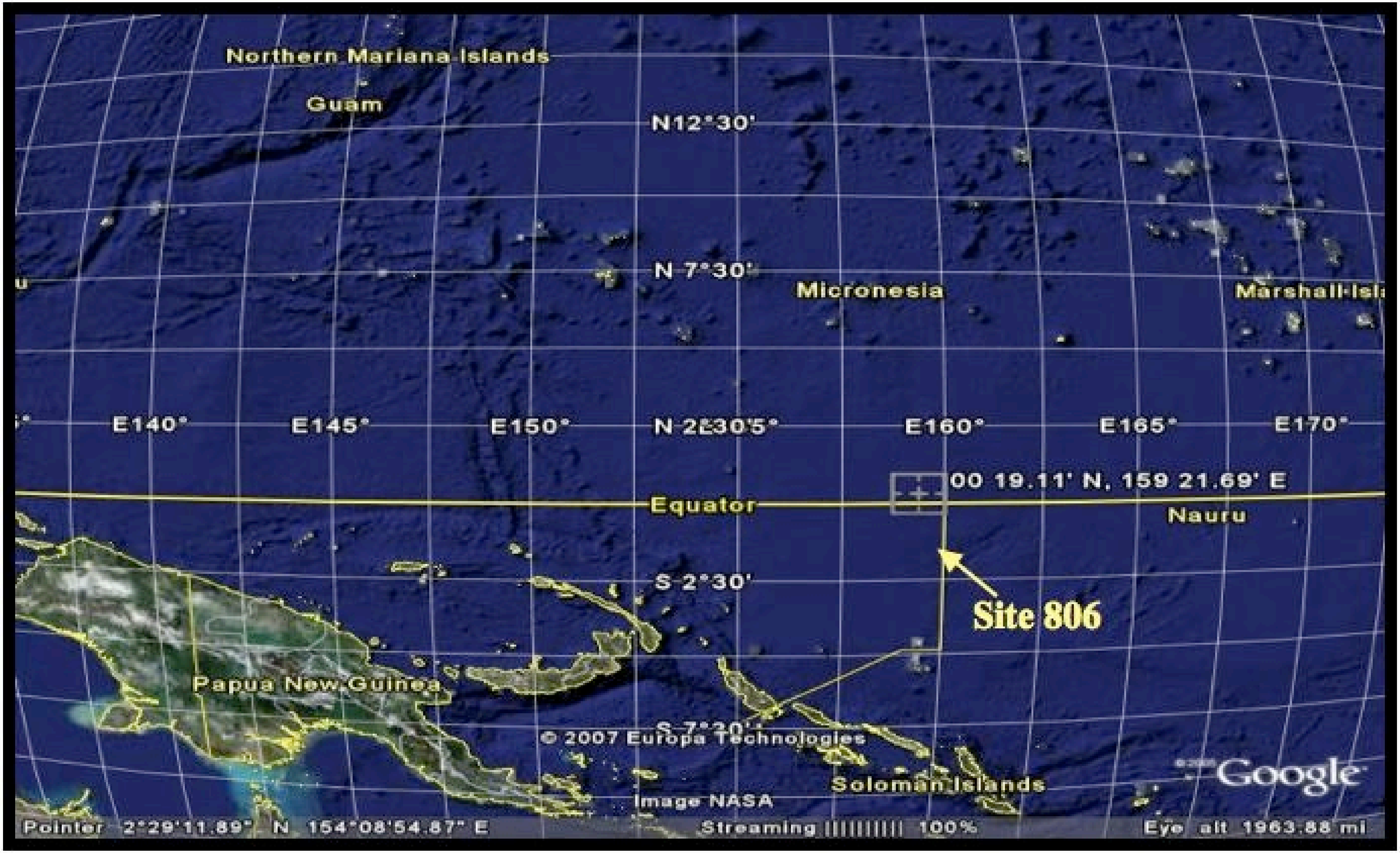
- Standard A: Science as Inquiry
- Standard C: Life Science
- Standard D: Earth and Space Science

Biology/Geology Connections: Cells…Ecosystem….Fossils)

Ocean Literacy Essential Principles: (1-5)

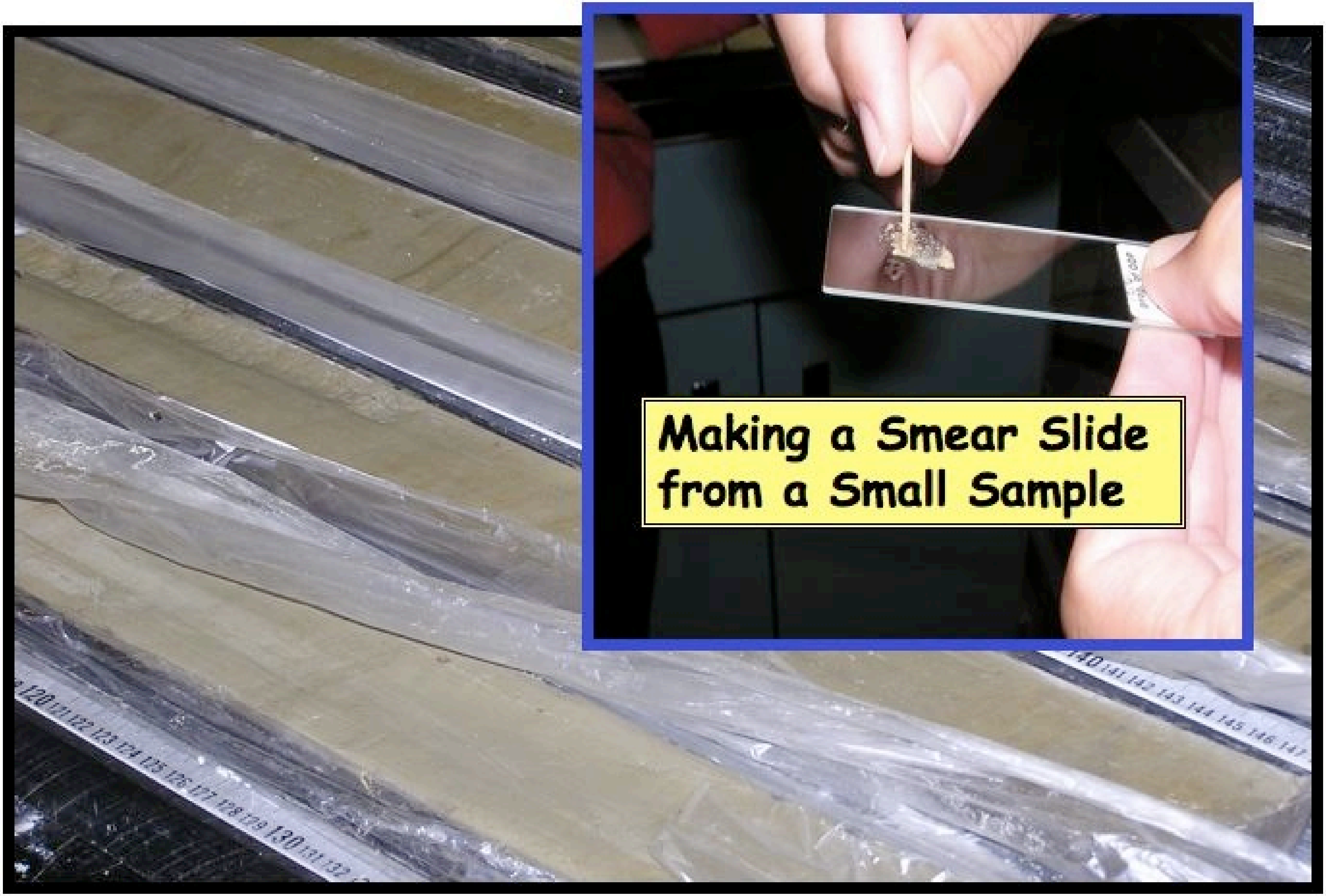
The Earth has one big ocean with many features; ocean and life in the ocean shape the features of Earth; The ocean is a major influence on weather and climate; The ocean makes the Earth habitable; The ocean supports great diversity of life and ecosystems.

Google Earth, Site 806, Leg 130: Western Equatorial Pacific

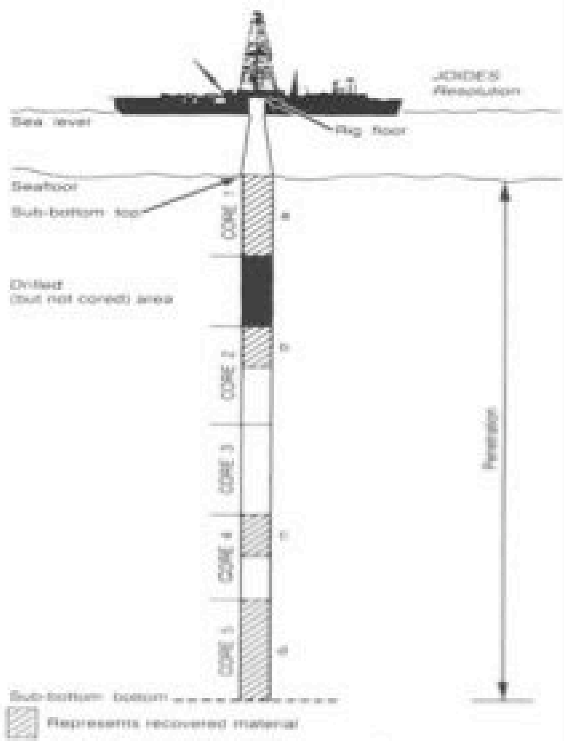


Introductory Activity: *Where in the World is Site 806?*

Evidence from the Past *Locked up* in the Cores



SHIPBOARD SCIENTIFIC PARTY



BOTTOM FELT: distance from rig floor to seafloor

TOTAL DEPTH: distance from rig floor to bottom of hole (sub-bottom bottom)

PENETRATION: distance from seafloor to bottom of hole (sub-bottom bottom)

NUMBER OF CORES: total of all cores recorded, including cores with no recovery

TOTAL LENGTH OF CORED SECTION: distance from sub-bottom top to sub-bottom bottom minus drilled (but not cored) areas in between

TOTAL CORE RECOVERED: total from adding a, b, c, and d in diagram

CORE RECOVERY (%): equals TOTAL CORE RECOVERED divided by TOTAL LENGTH OF CORED SECTION times 100

Figure 1. Coring and depth intervals.

Coring and Depth Intervals

ODP Leg 130 "Hole 806 B"

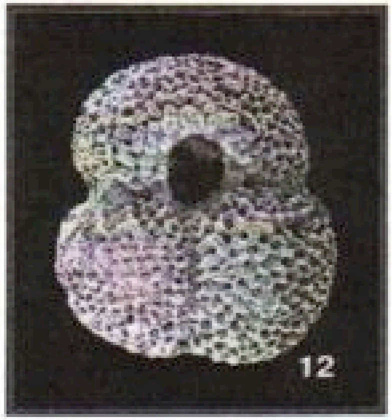
Drilling Vessel: *JOIDES Resolution*

February 18, 1990 – February 22, 1990

(Time at Drill Site: 4 days, 4 hours, 30 min.)

- **Water Depth**: (from sea level) 2519.9 m
- **Penetration through seafloor**: 743.10 m
  (mbsf = meters below sea floor)
- **Number of Cores**: 78
- **Total Length of Core Section**: 743.10 m
- **Core Recovery**: 89%
- **230 samples examined...**
  (110 planktonic foraminifer species identified)

Foram Bio Cards

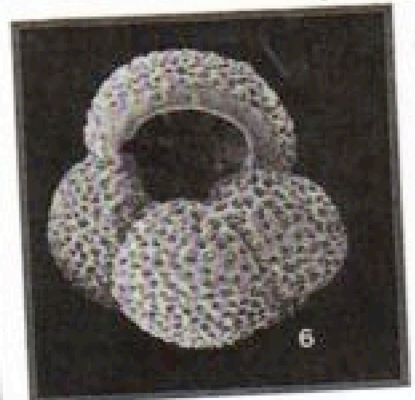


Globigerinoides subquadratus
"Cyclops one"

Site 806
Surface Dweller
early Miocene-middle Miocene

Zone: mid N4b - base of N14

- Planktonic
- Had two pulses in the mid Miocene, which indicated changes in the surface ocean
- Abundance coincided with decrease in *G. glutinata*

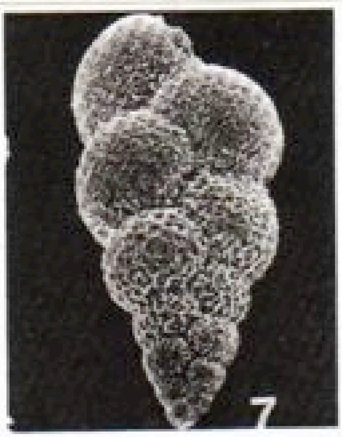


Globigerina apertura
"Big mouth"

Site 806
Thermocline Dweller
late Miocene-late Pliocene

Subzone: N17-N18/N19

- Planktonic
- Marked abundance in late Miocene – early Pliocene
- Increase in *N. dutertrei* parallels with gradual demise of *G. apertura*



Streptochilus globigerum
"Icecream cone"

Site 806
Deep Dweller
middle Miocene-early Pliocene

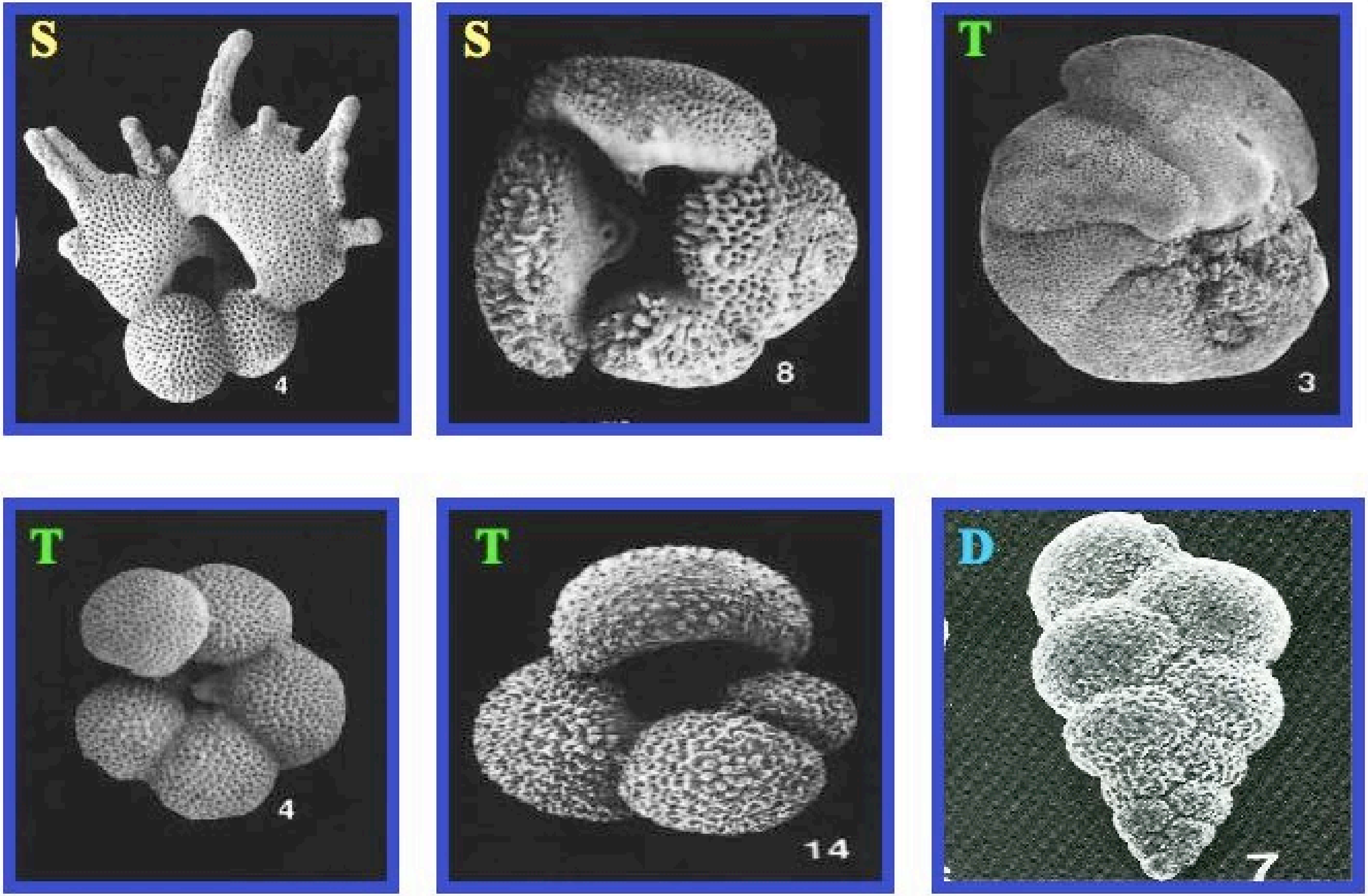
Zone: top of N6- upper N22/23

- Planktonic
- One of deepest dwelling genera of modern planktonic foraminifers
- Abundant throughout late Miocene and much of Pliocene at 806

19 Dominant Taxa in Hole 806 B

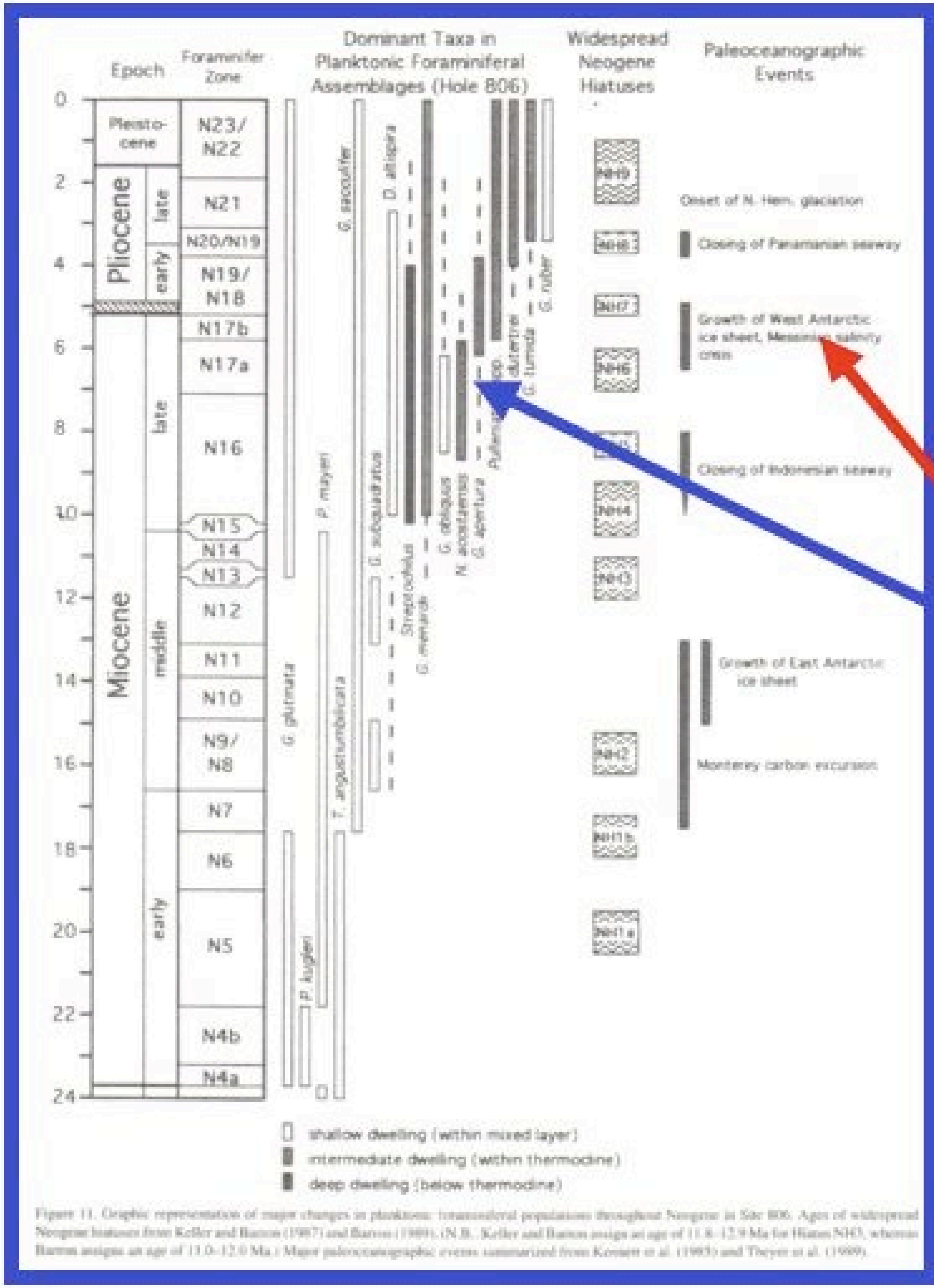
The *nickname* listed under the *formal name* also mimics *Linnean Binomial Nomenclature* (*i.e., Genius species*)

Foraminifers…*Note the Diverse Shell Structure*



Warm Water Upwelling Indicator Species

Cold Water Upwelling Indicator Species



Graphic Representation
"Figure 11"

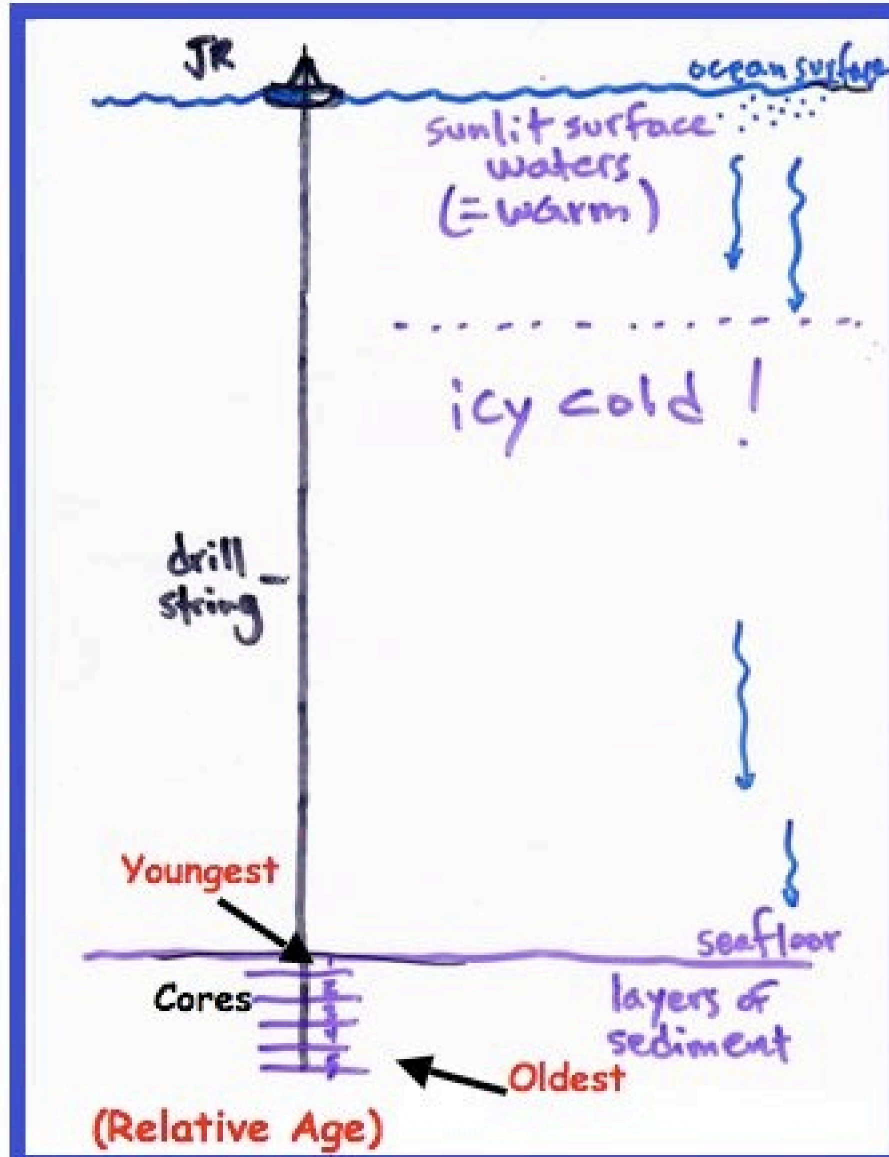
"Distribution Table" will be built by students using this data

- Paleoceanographic Events
- Dominant Taxa in Planktonic Foraminiferal Assemblages, Hole 806

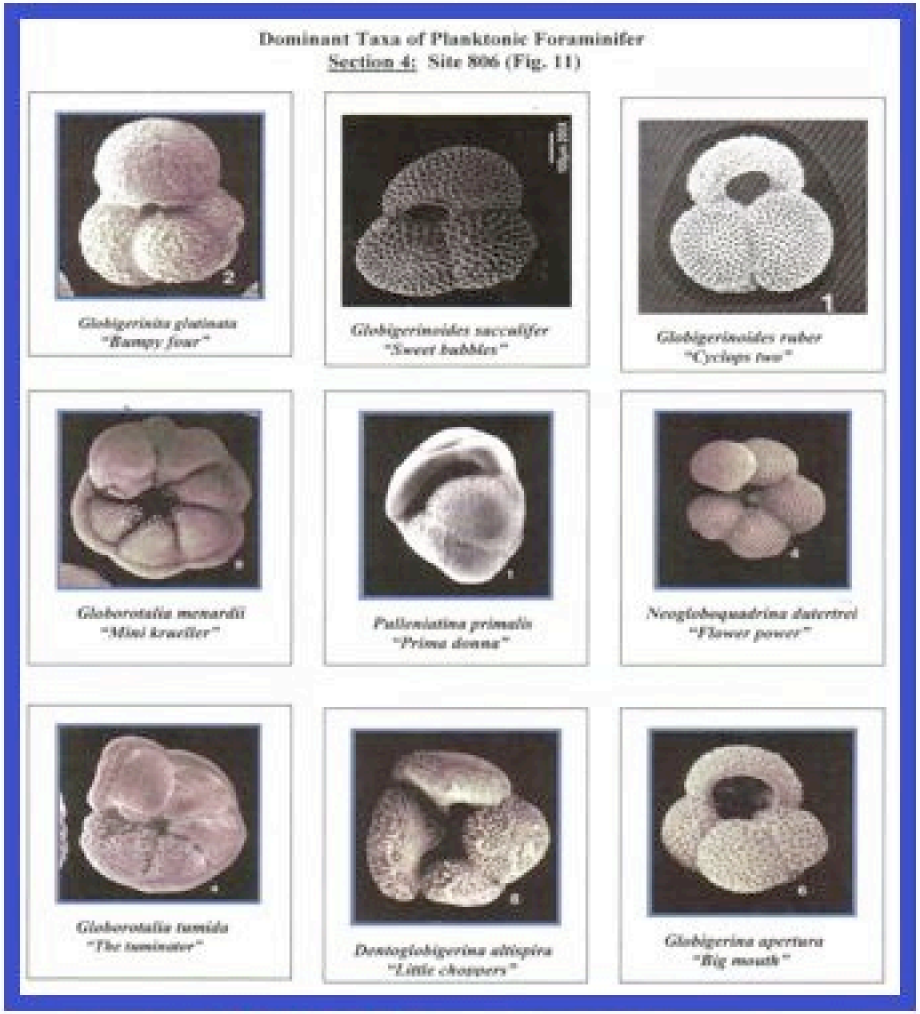
Ontong Java Plateau,
Western Equatorial Pacific

Using Foram Bio Cards to Categorize the Forams

Making the Connection: How did Forams get into the sediment?

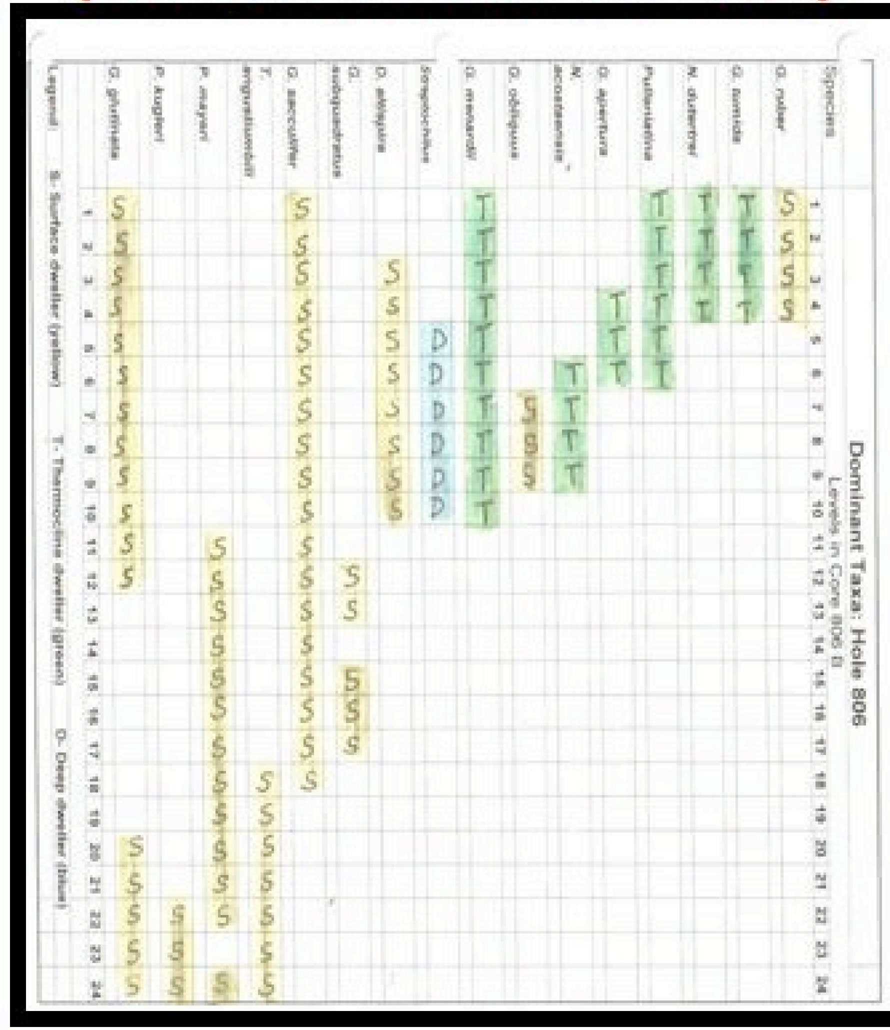


24 *Section* Cards:
Section Card 4



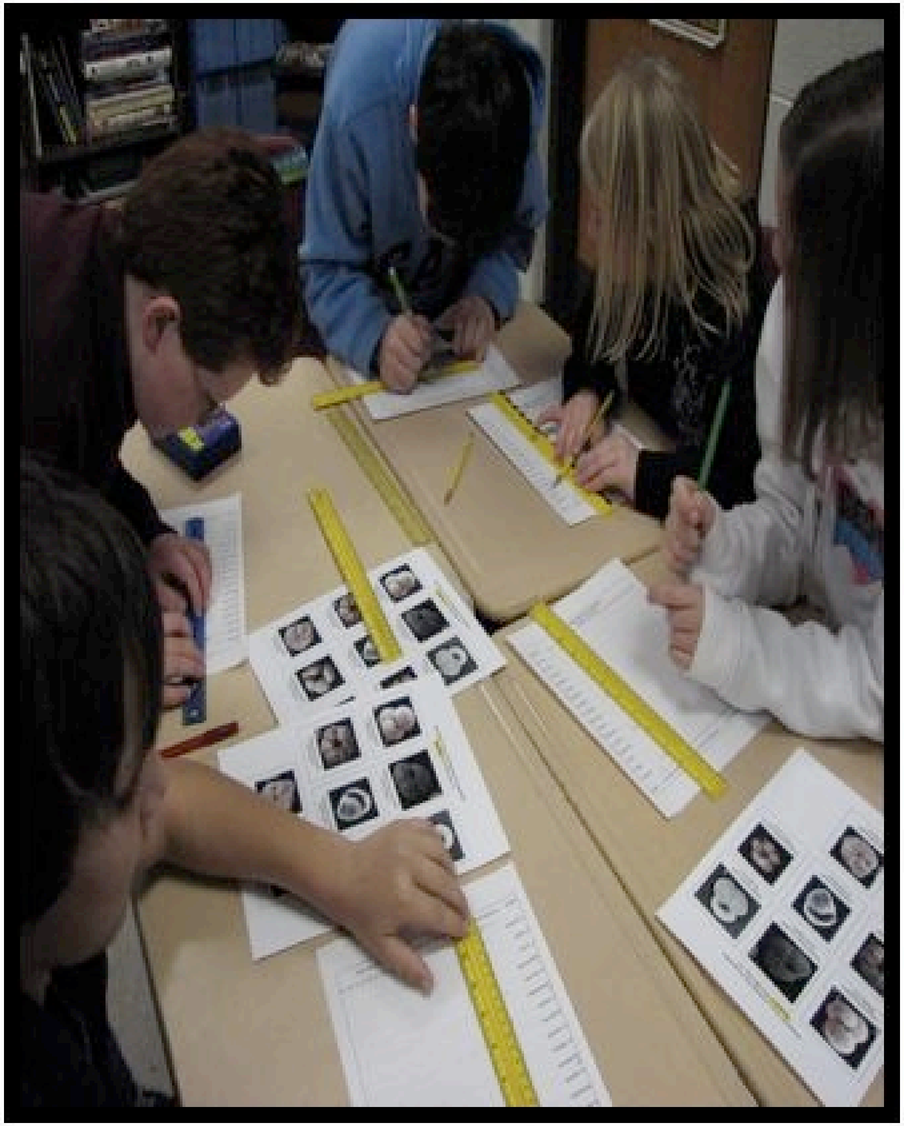
Build Figure 11 one section at a time from the bottom to the top (oldest to youngest).

Graphic Representation
(Find Section 4 on the chart)

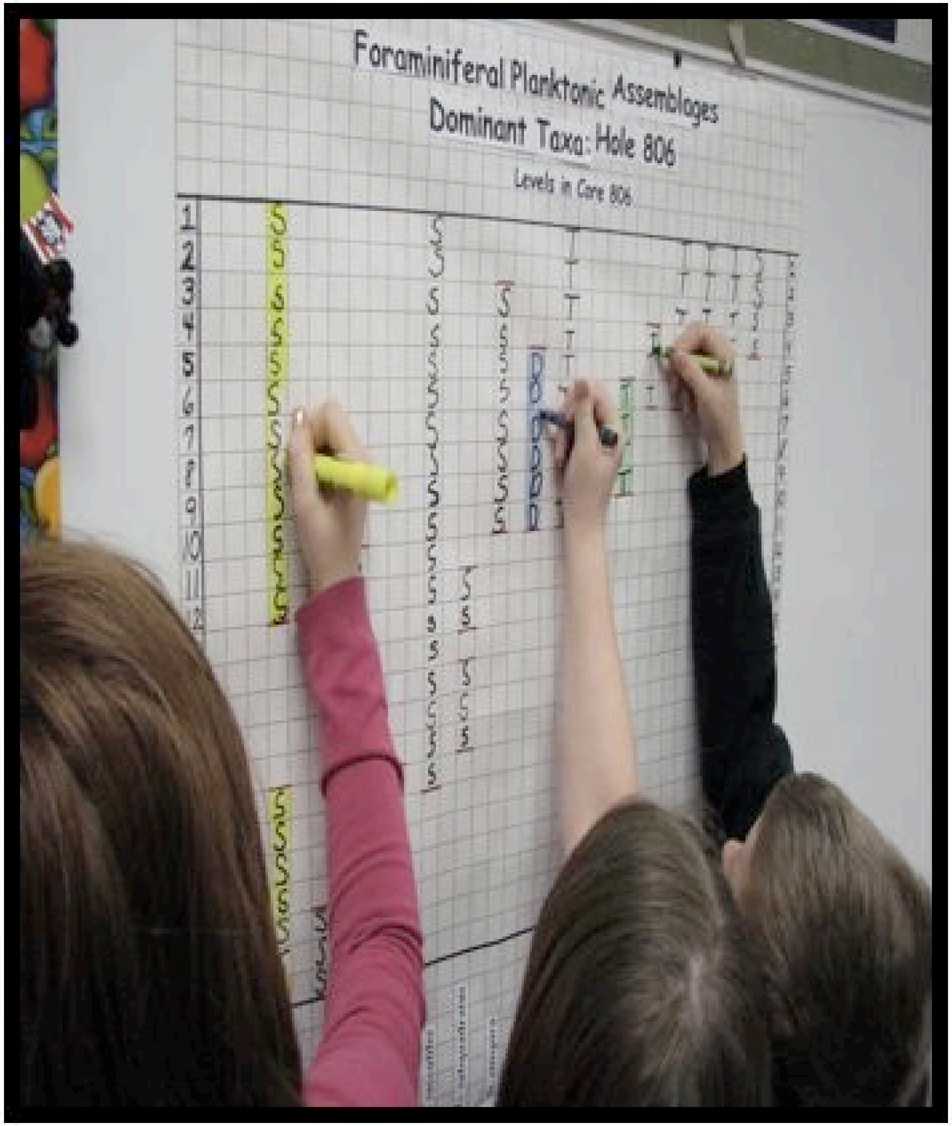


The Foram Bio Cards indicate where the planktic forams live in the water column: Surface, Thermocline, or Deep.

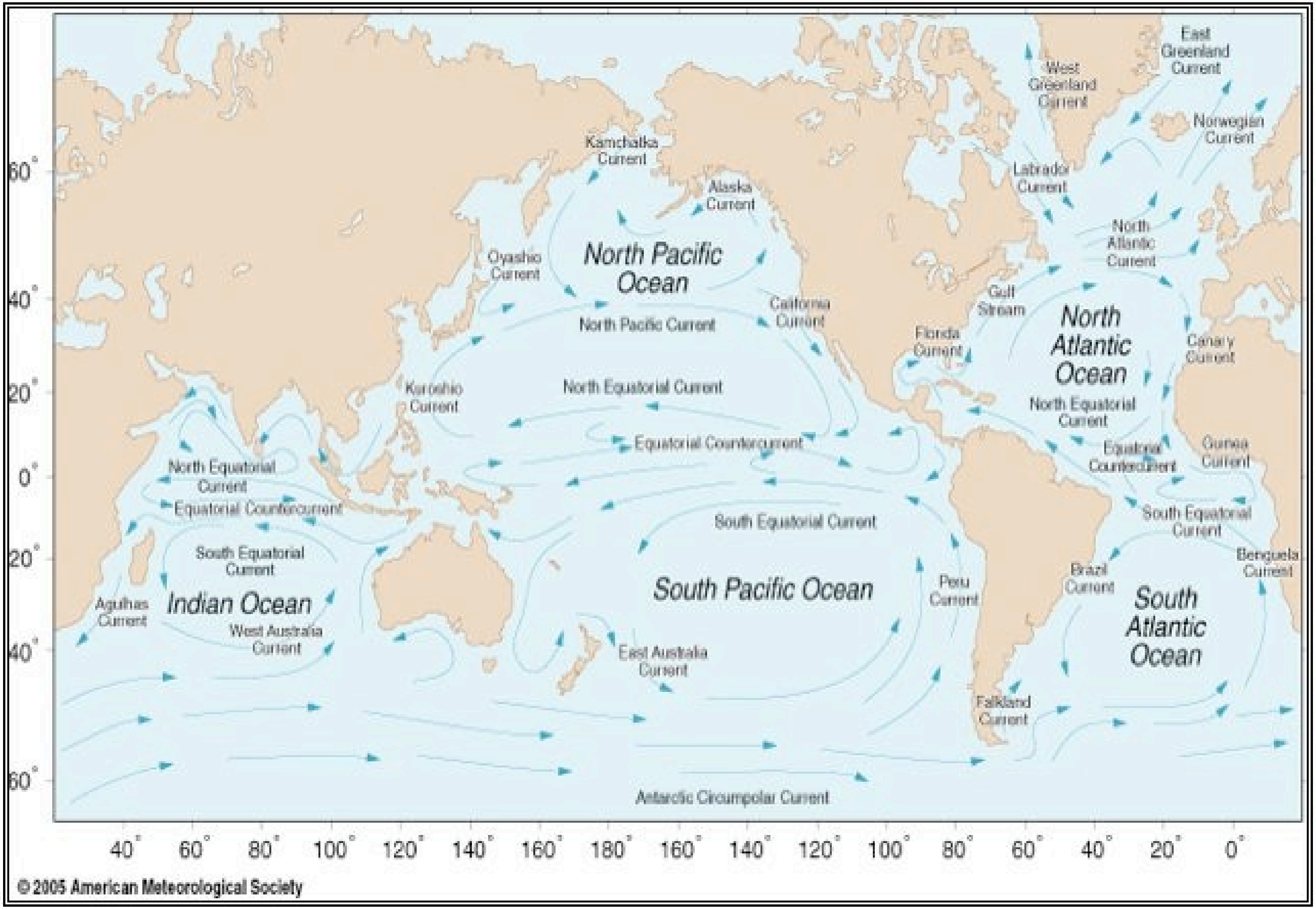
Building the Graphic Representation Together



Individual Data Charts



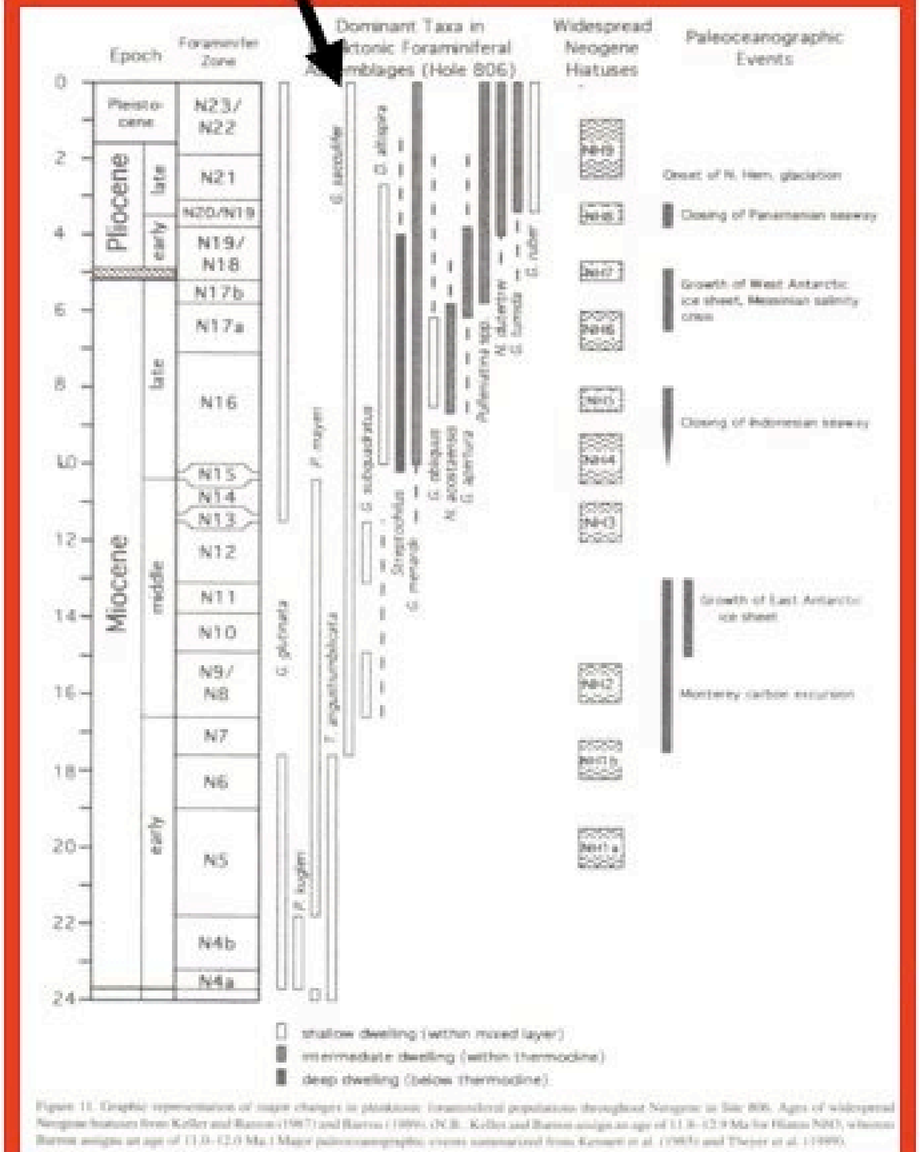
Group Chart to Share Data

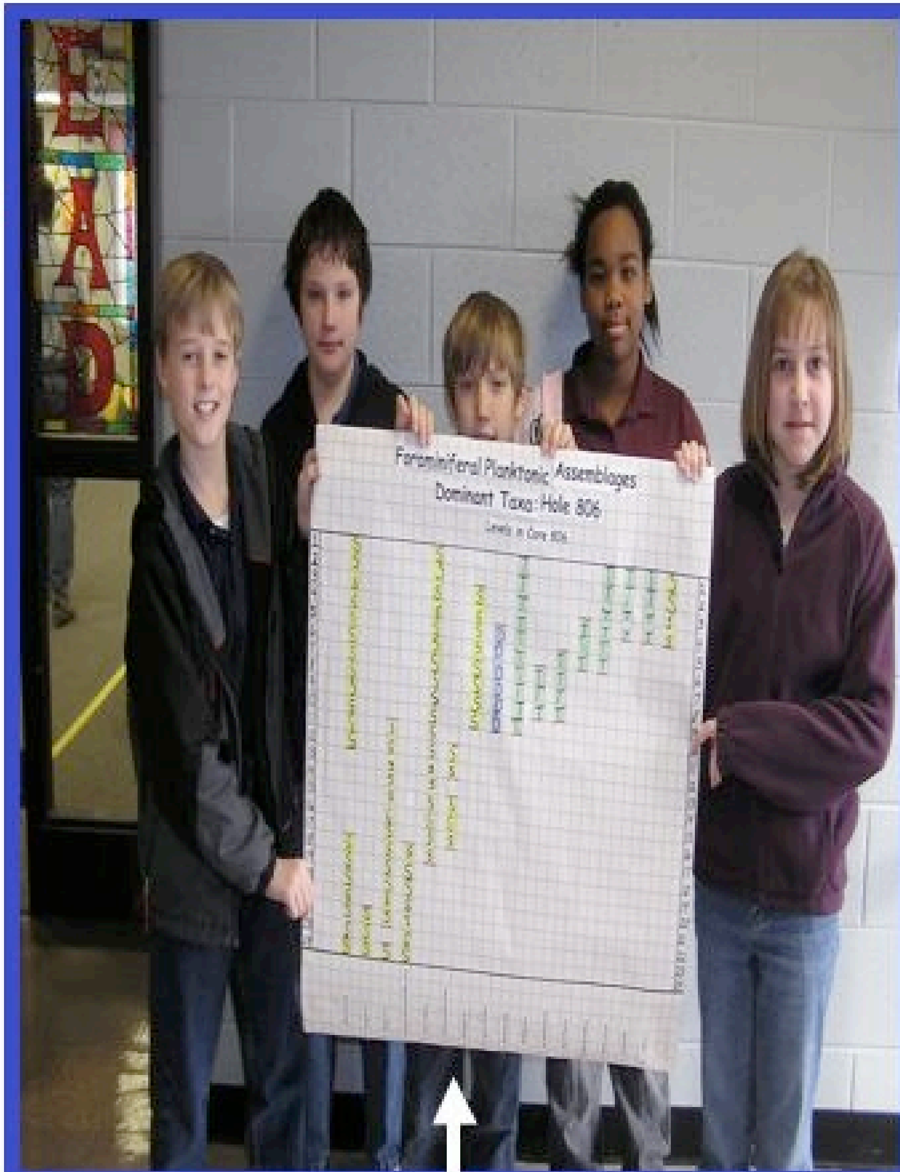


Present-day circulation in the Pacific: faster current and more nutrients.

Image: http://oceanmotion.org/images/surface_current_map.jpg

Figure 11, *Authentic* Data Scientific Report, Leg 130





Graphic Representation
Figure 11, Built by Students

Connecting Students to Learning

- *Collaborating*
- *Communicating*
- *Investigating*
- *Comparing*
- *Analyzing*
- *Discussing*
- *Building Content*

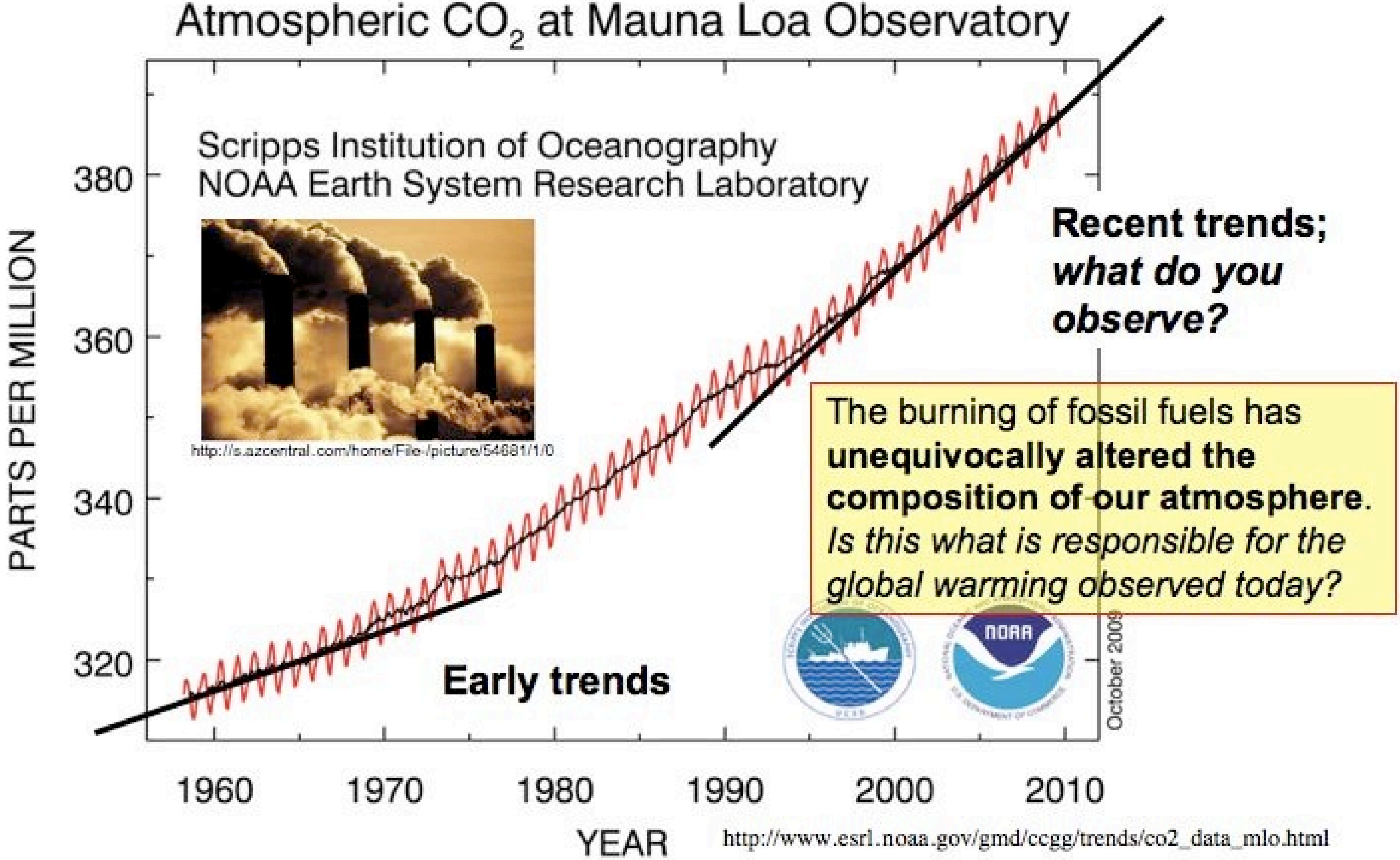
- Opening Minds
- Opening Ears

Is Climate Change Real?
A Marine Perspective

Let's consider the following observations and facts spanning **the present** and our **geologic past**….

R. Mark Leckie
Department of Geosciences
University of Massachusetts
mleckie@geo.umass.edu

Monthly mean atmospheric CO_2 at Mauna Loa (since 1958)



This may seem counter-intuitive, but **the process of <u>science is very conservative</u>**

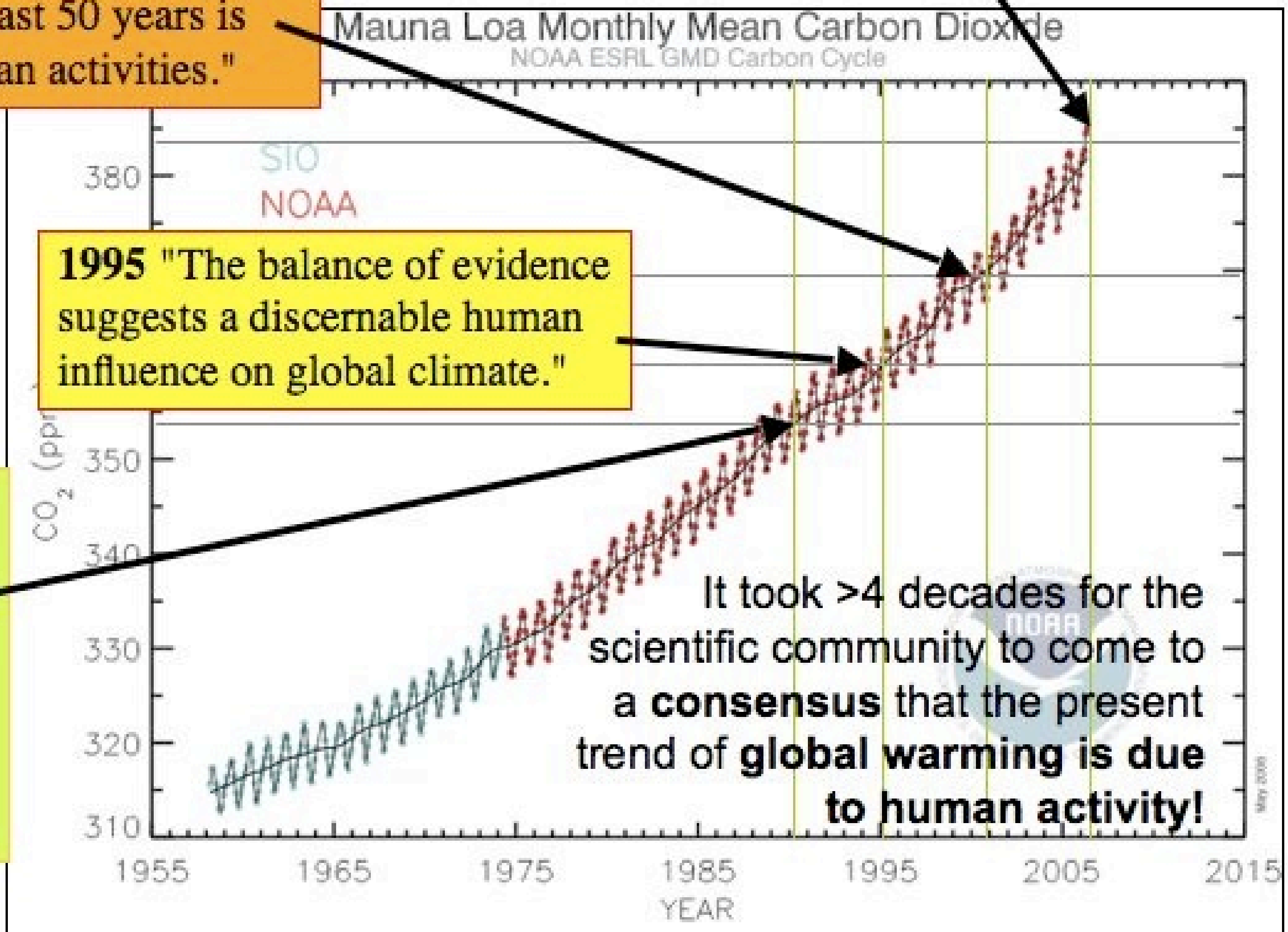
2007 "Most of the observed increase in globally averaged temperatures since the mid-20th century is **very likely due to the observed increase in anthropogenic greenhouse gas concentrations**."

2001 "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

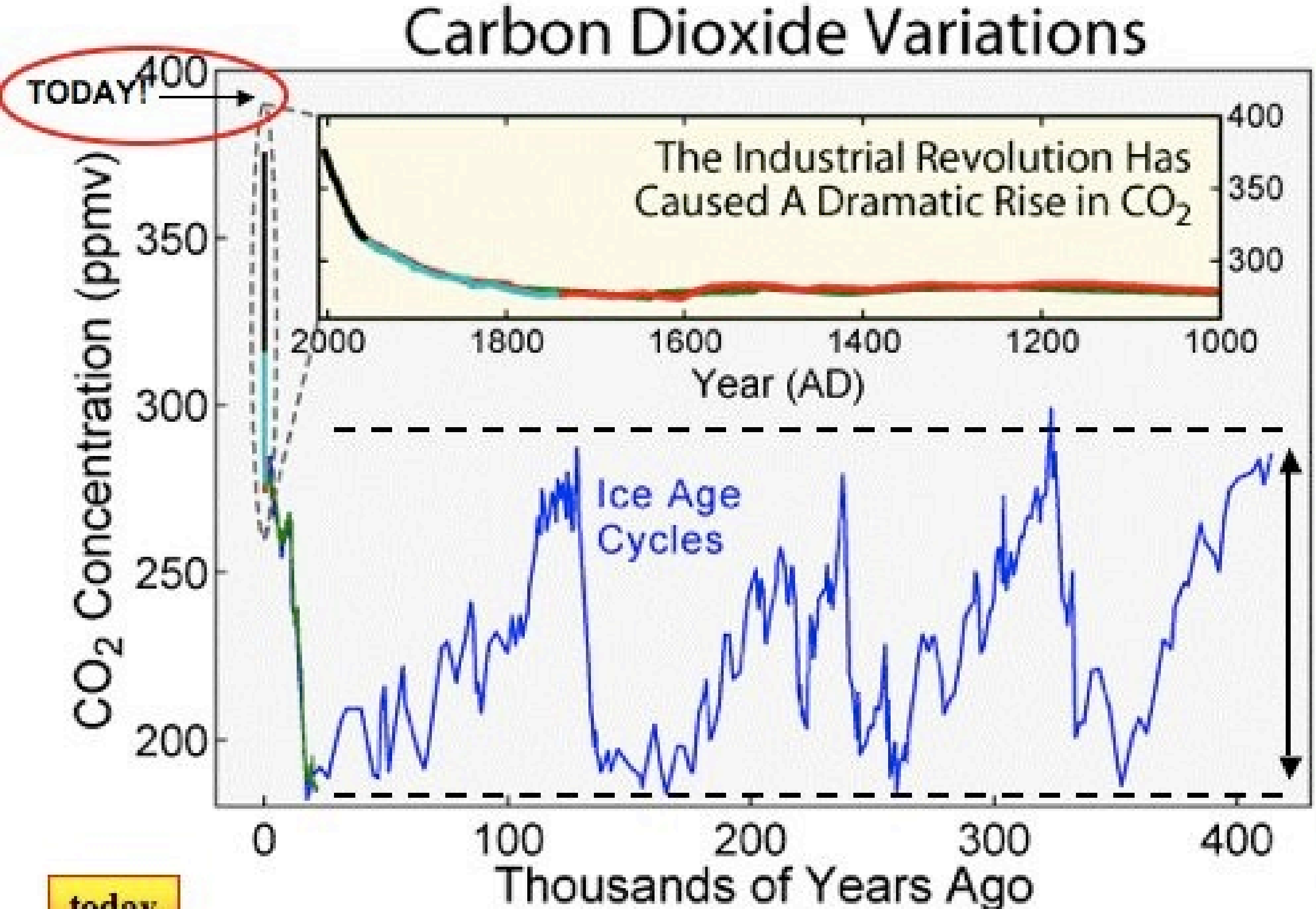
Conclusions of Intergovernmental Panel on Climate Change (ICCP) Reports

1995 "The balance of evidence suggests a discernable human influence on global climate."

1990 "The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more."

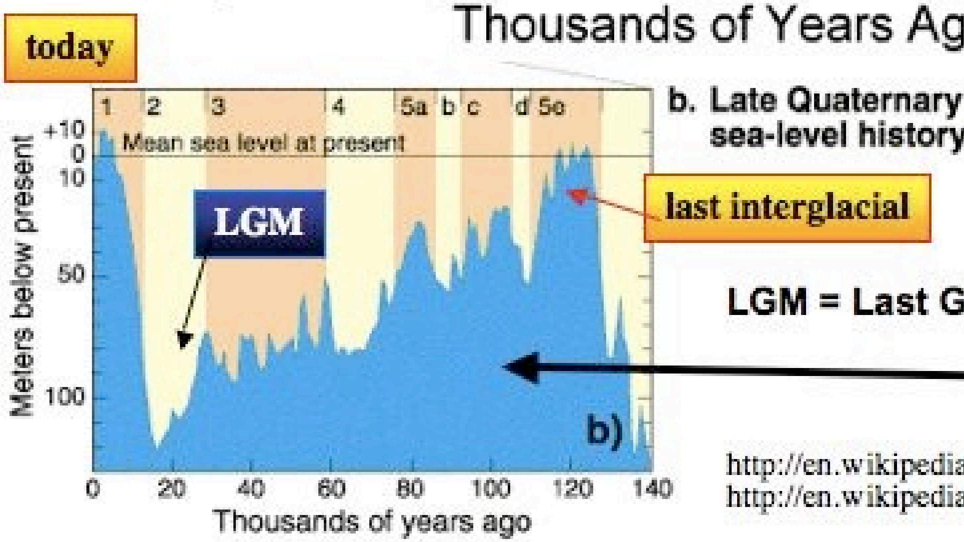


It took >4 decades for the scientific community to come to a **consensus** that the present trend of **global warming is due to human activity!**



Ice-core records of **changing atmospheric CO_2** concentrations of the past 400,000+ years

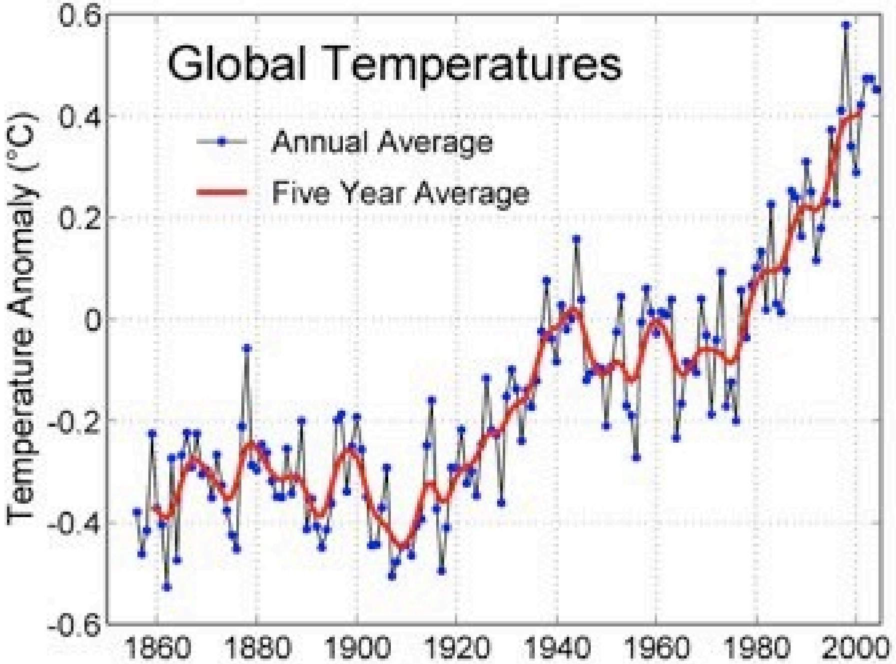
The pre-Industrial Revolution __natural range of CO_2 variability__ was ~190-290 ppm. Today we are at 390 ppm!



LGM = Last Glacial Maximum

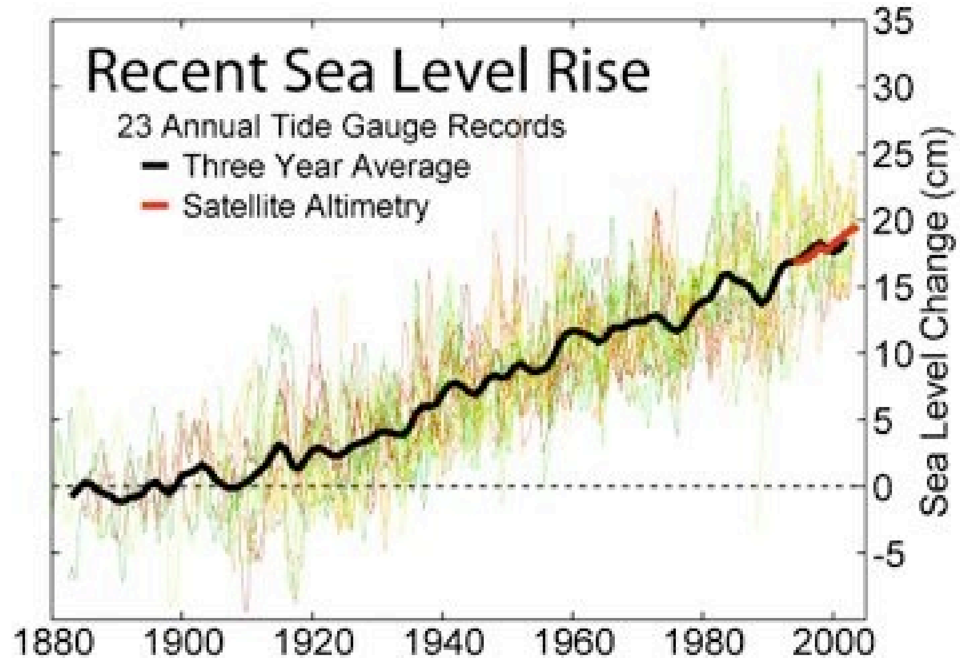
Note the striking parallel with **changing global sea level**

http://en.wikipedia.org/wiki/Milankovitch_cycles
http://en.wikipedia.org/wiki/Sea_level_rise



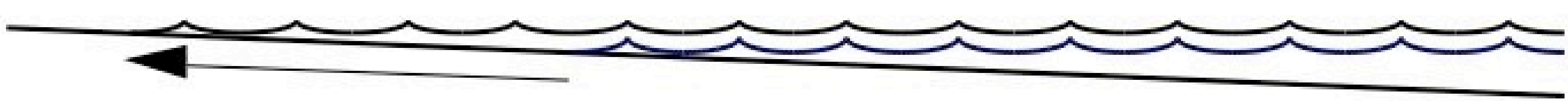
http://en.wikipedia.org/wiki/Global_warming

Global warming and rising global sea level: melting ice and thermal expansion of seawater

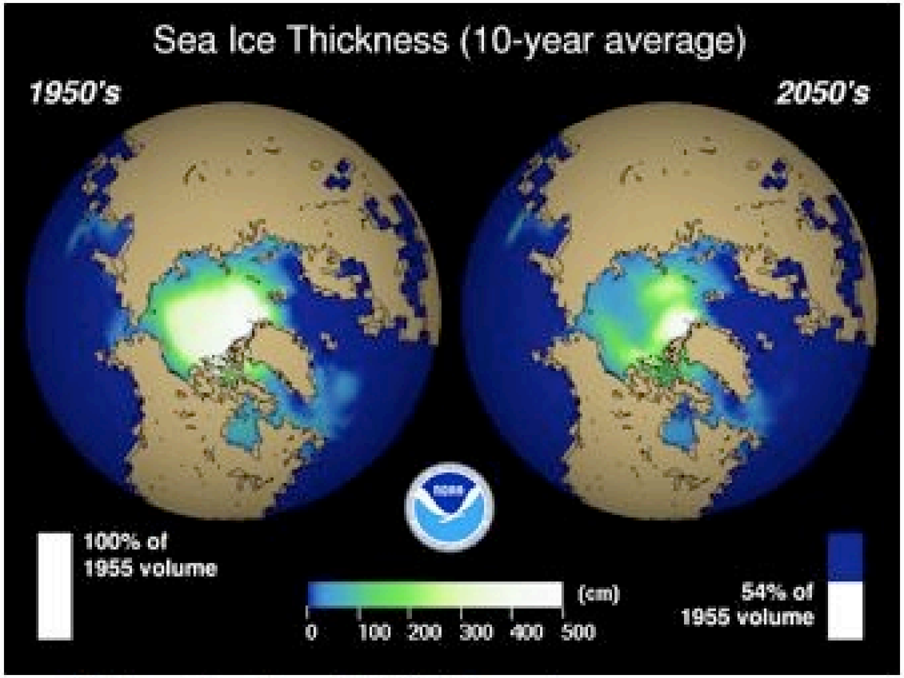


http://en.wikipedia.org/wiki/Sea_level_rise

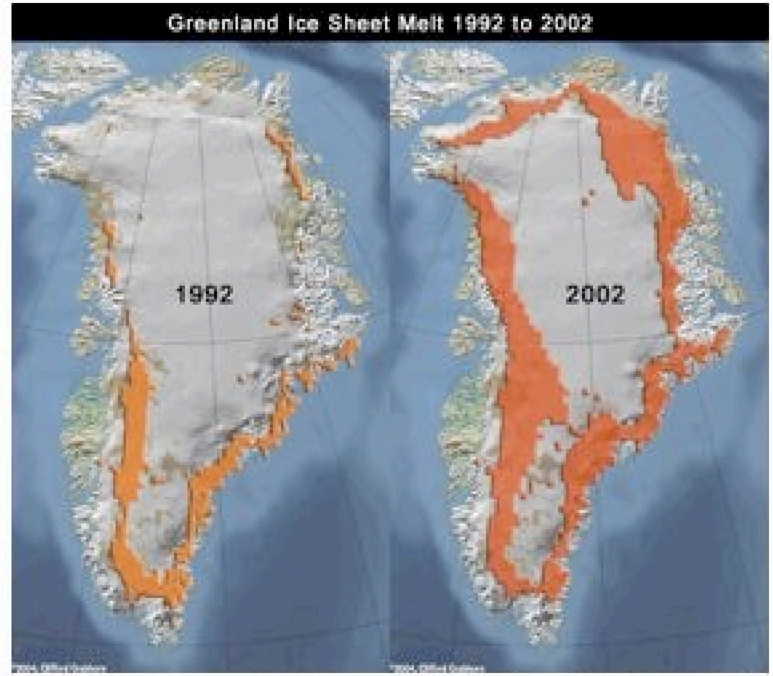
A **small rise in sea level** translates into a much **greater inundation of the coast!**



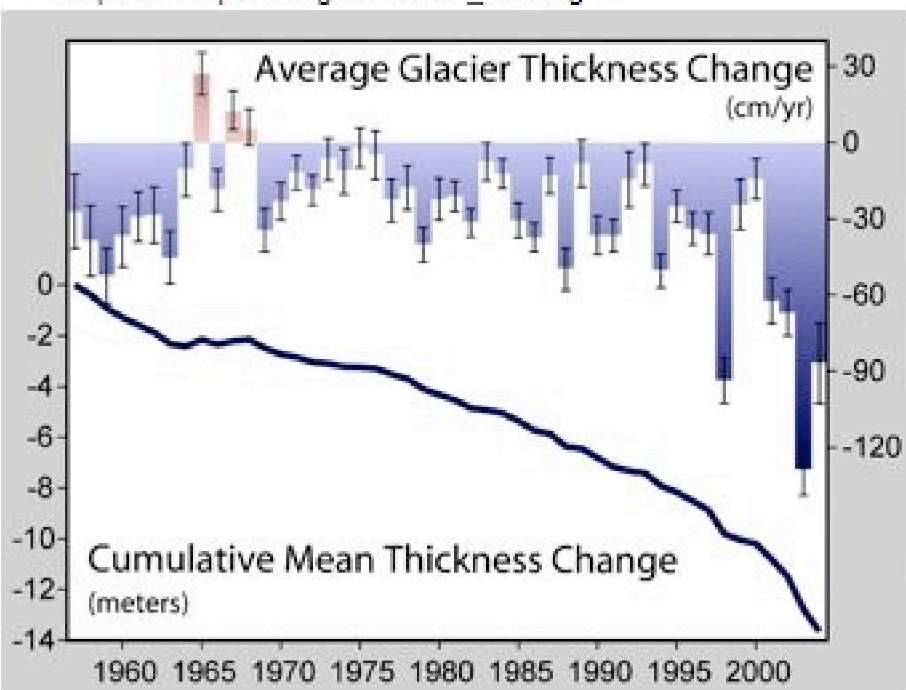
Rising sea level: Cape Hatteras, North Carolina



http://en.wikipedia.org/wiki/Global_warming



http://www.ec.gc.ca/EnviroZine/images/Issue48/melt_e_l.gif

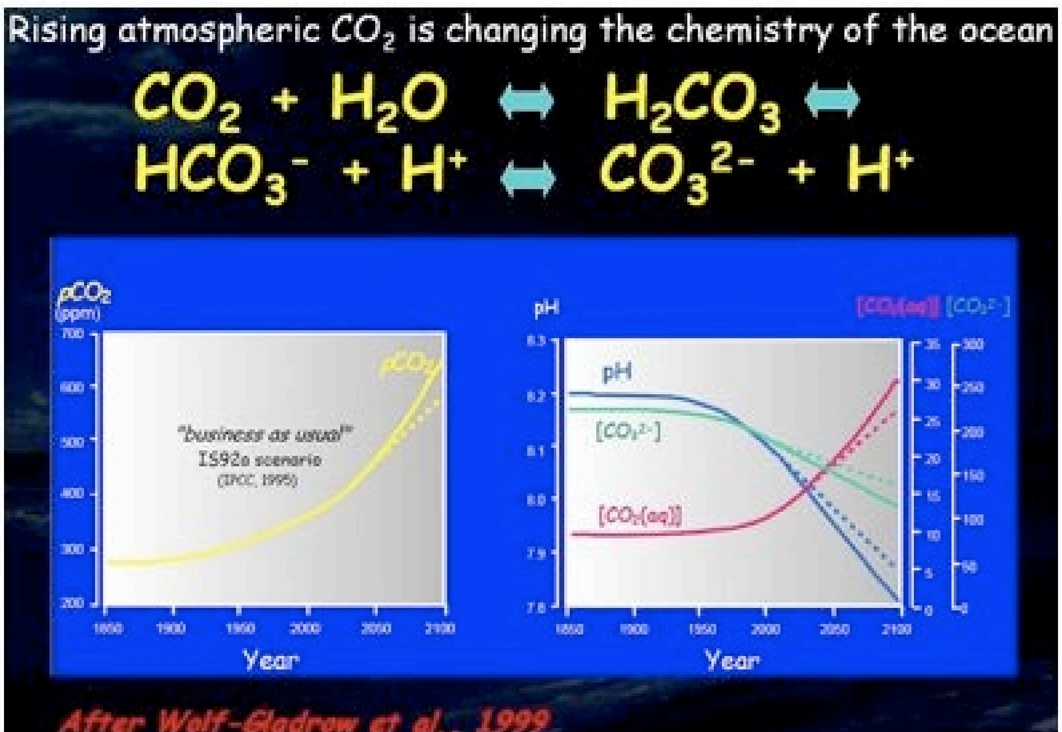


- Greenland and West Antarctic **ice sheets are shrinking** (= 13+ m/40+ ft. of eustatic **sea level rise**)
- **Alpine glaciers are shrinking** around the world.
- Arctic seasonal **sea ice is shrinking.**
- **Sea level is rising** due to the melting of ice and warming of the surface ocean.

http://en.wikipedia.org/wiki/File:Glacier_Mass_Balance.png

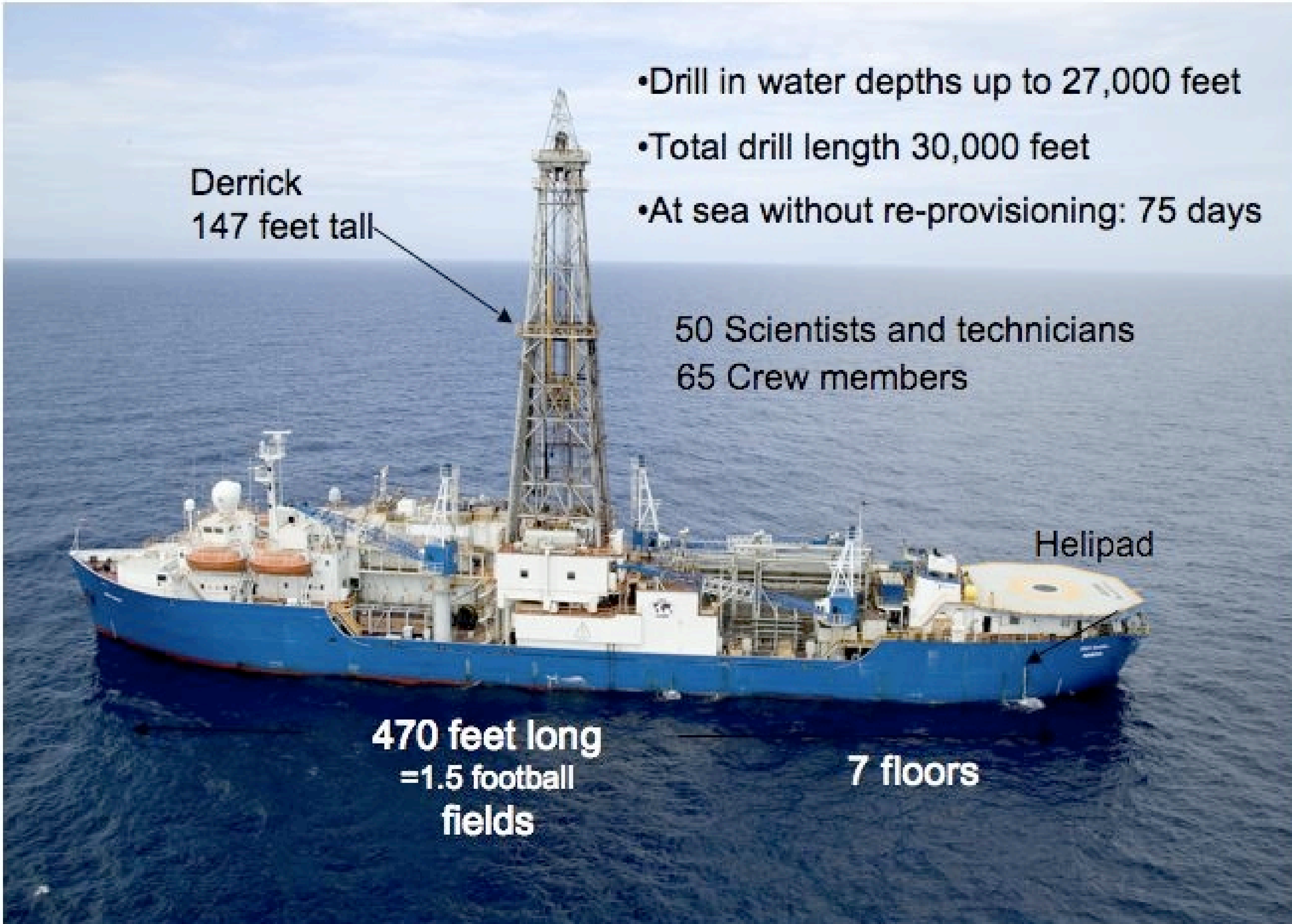
Rising CO_2 is changing the chemistry of the ocean (including the lowering of ocean pH)

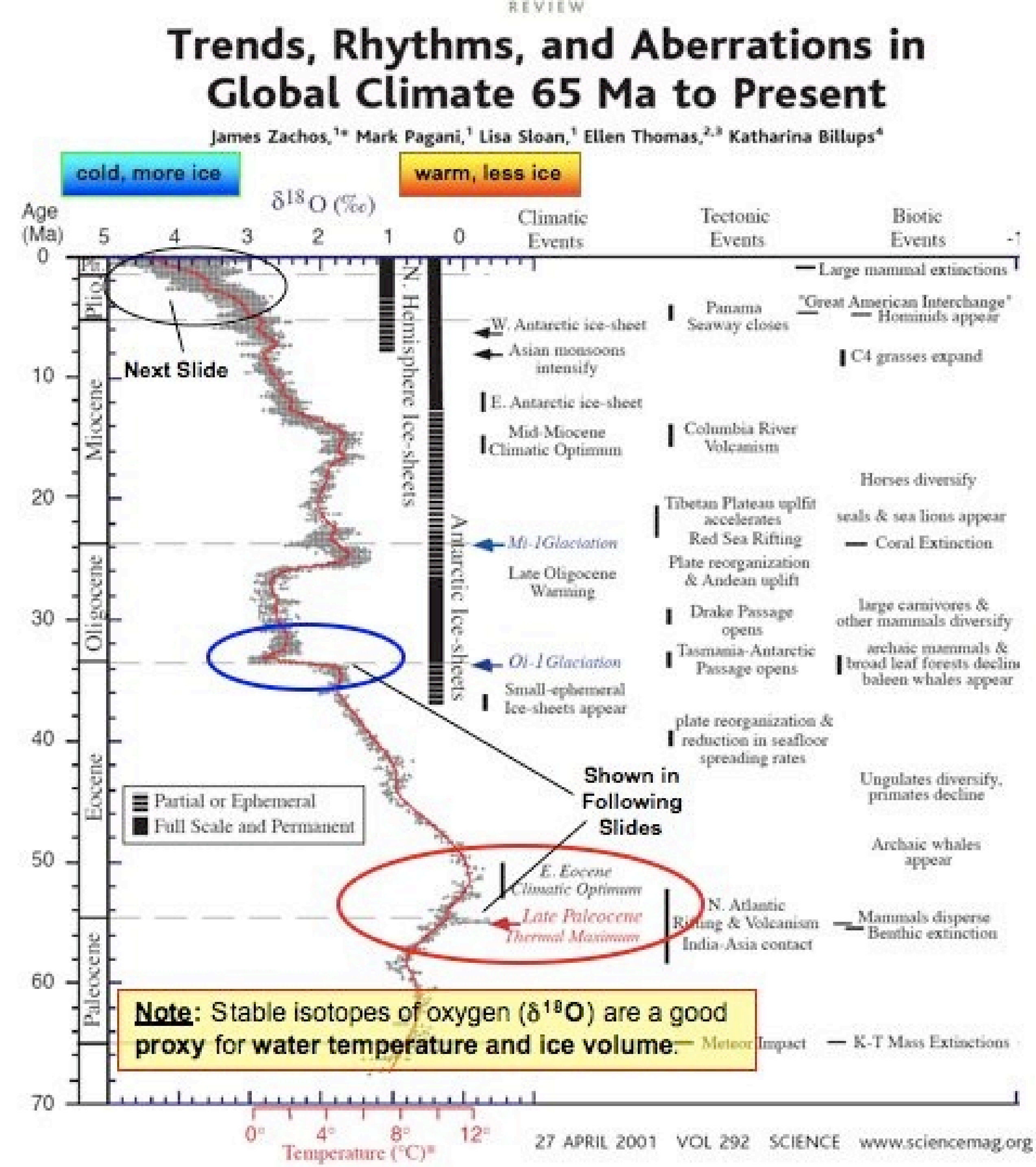
http://www.pmel.noaa.gov/co2/OA/OA1.jpg



Ocean acidification has also happened in the past during times of greenhouse (warm) climates!

JOIDES Resolution fast facts

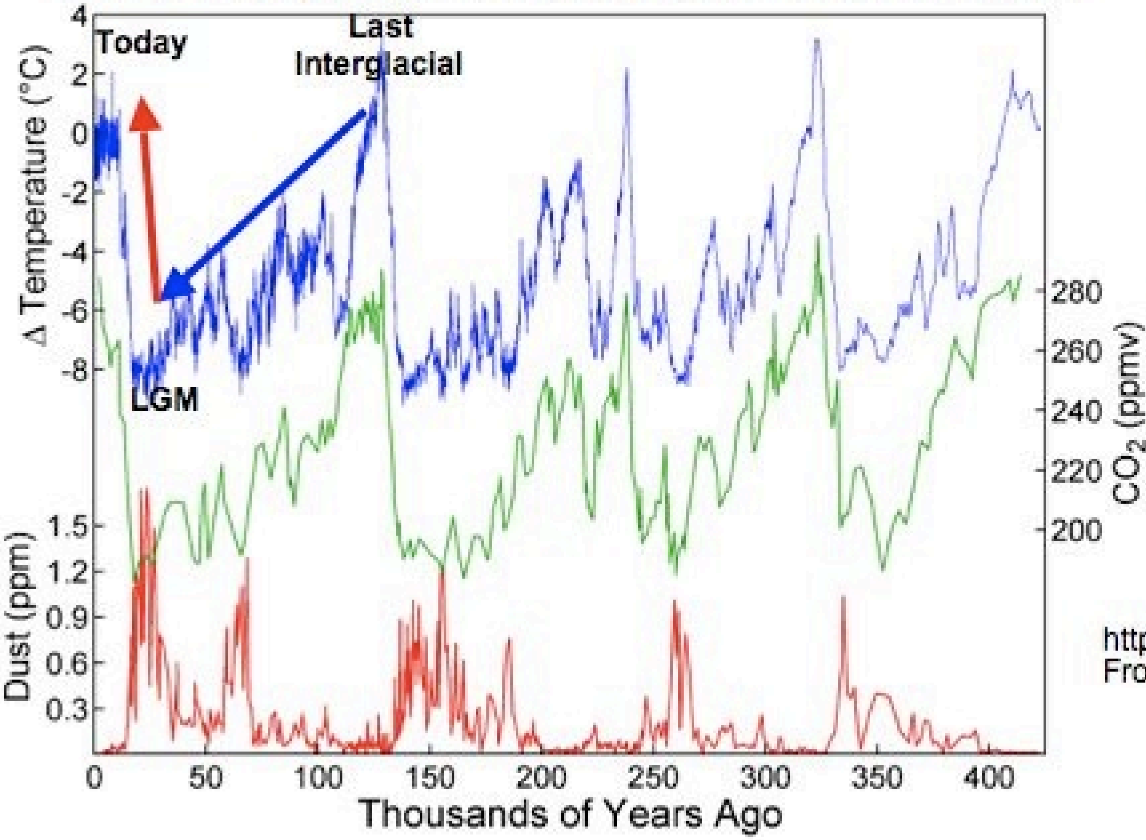




Global climate change over the Cenozoic Era (past 65 million years) has been **both gradual and abrupt.**

- The recognition of abrupt **climate change on time scales of millennia to centuries** is one of the most important discoveries of **scientific ocean drilling** over the past 20 years.
- The Paleocene-Eocene Thermal Maximum (**PETM**, ~55 Ma) and Eocene-Oligocene **Oi1 Event** (~33.7 Ma) are examples of **abrupt warming and cooling events**, respectively.

Vostok (Antarctica) Ice Core Data

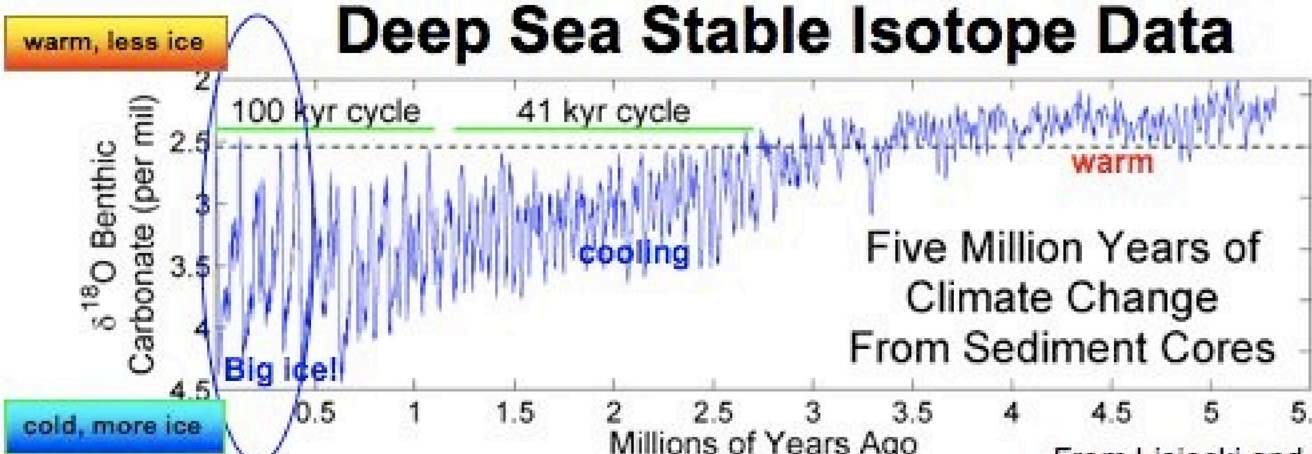


Last 4 glacial cycles of the past 400,000 years:

- **Gradual build-up of large ice-sheets** in the Northern Hemisphere; **<u>rapid/abrupt warming</u>** ("terminations")
- Distinctive **"saw-tooth"** pattern
- Last interglacial ~130 kyr, Last Glacial Maximum (**LGM**) ~20 kyr

http://en.wikipedia.org/wiki/Greenhouse_gas
From Petit J.R. et al., (1999), *Nature*, 399: 429-436.

Deep Sea Stable Isotope Data

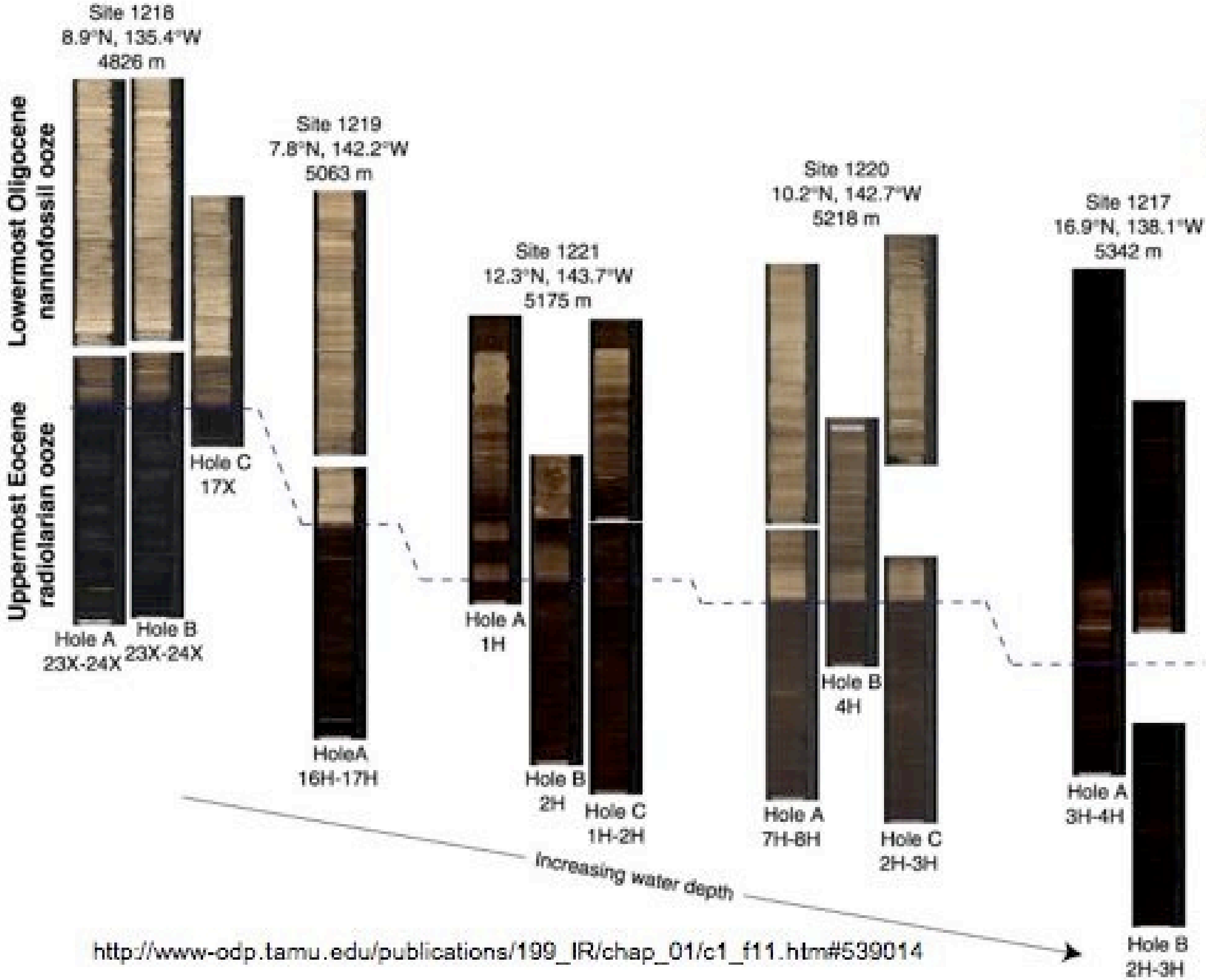


Last 5.5 Ma:

- **Warm** ~5.5-2.7 Ma
- **Cooling** and 41 kyr glacial cycles ~2.7-0.8 Ma
- **Very large ice-sheets** and 100 kyr glacial cycles ~0.8-0.2 Ma

http://en.wikipedia.org/wiki/Ice_age
From Lisiecki and Raymo (2005), *Paleoceanography*, 20.

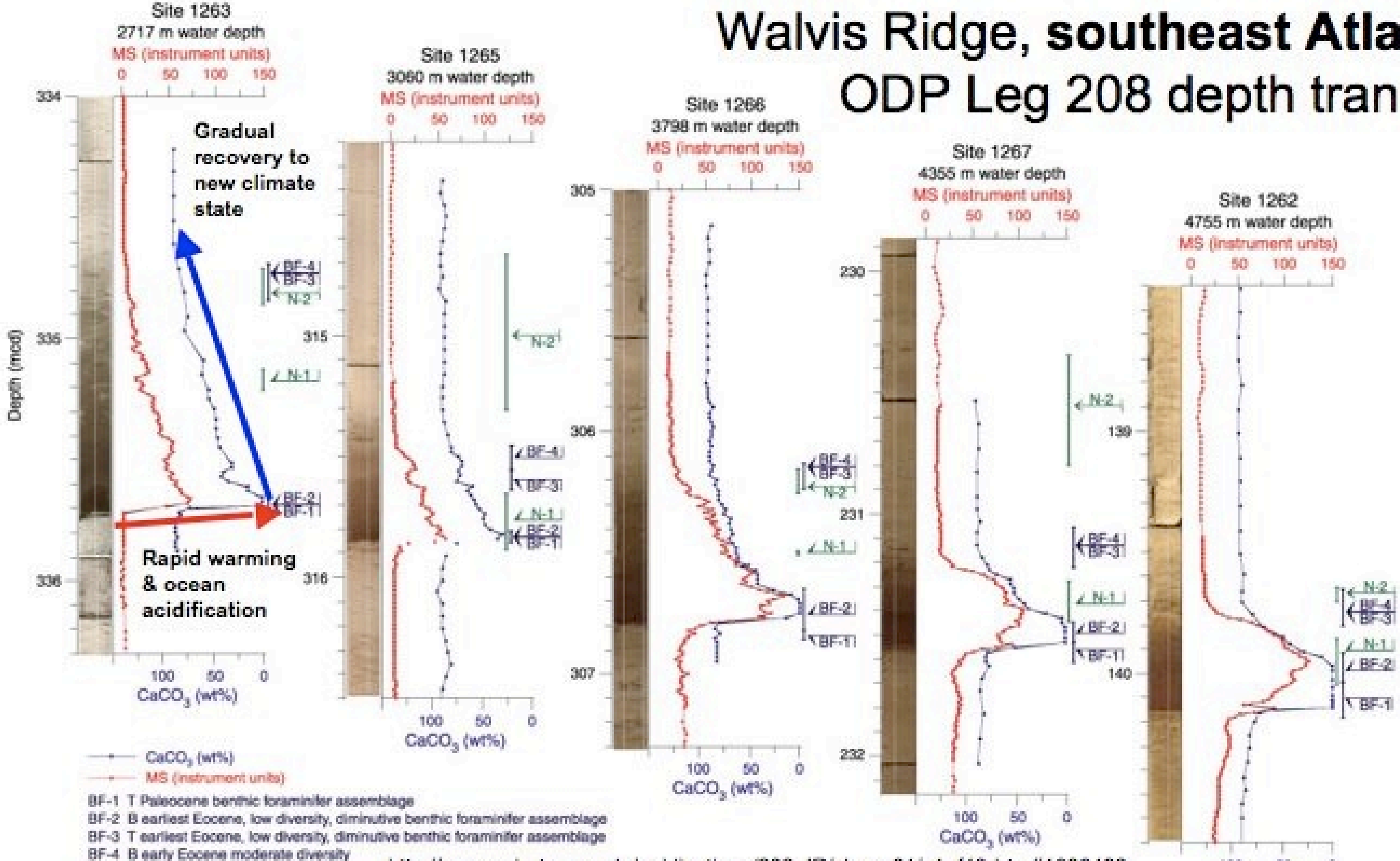
Oi1 event in the equatorial Pacific, ODP Leg 199



Composite digital images of cores taken across the **Eocene/Oligocene boundary (~33.7 Ma)** using the shipboard GEOTEK digital imaging system. At Site 1218 (shallowest site), it is clear that the Eocene-Oligocene carbonate transition occurs as a two-step shift.

This **rapid change in deep sea carbonate** is associated with the **rapid glaciation of Antarctica** (first large ice sheets).

Walvis Ridge, **southeast Atlantic**
ODP Leg 208 depth transect

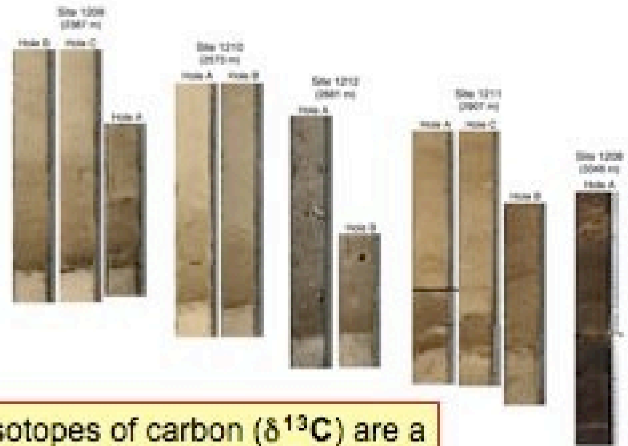


http://www-odp.tamu.edu/publications/208_IR/chap_01/c1_f48.htm#1036493

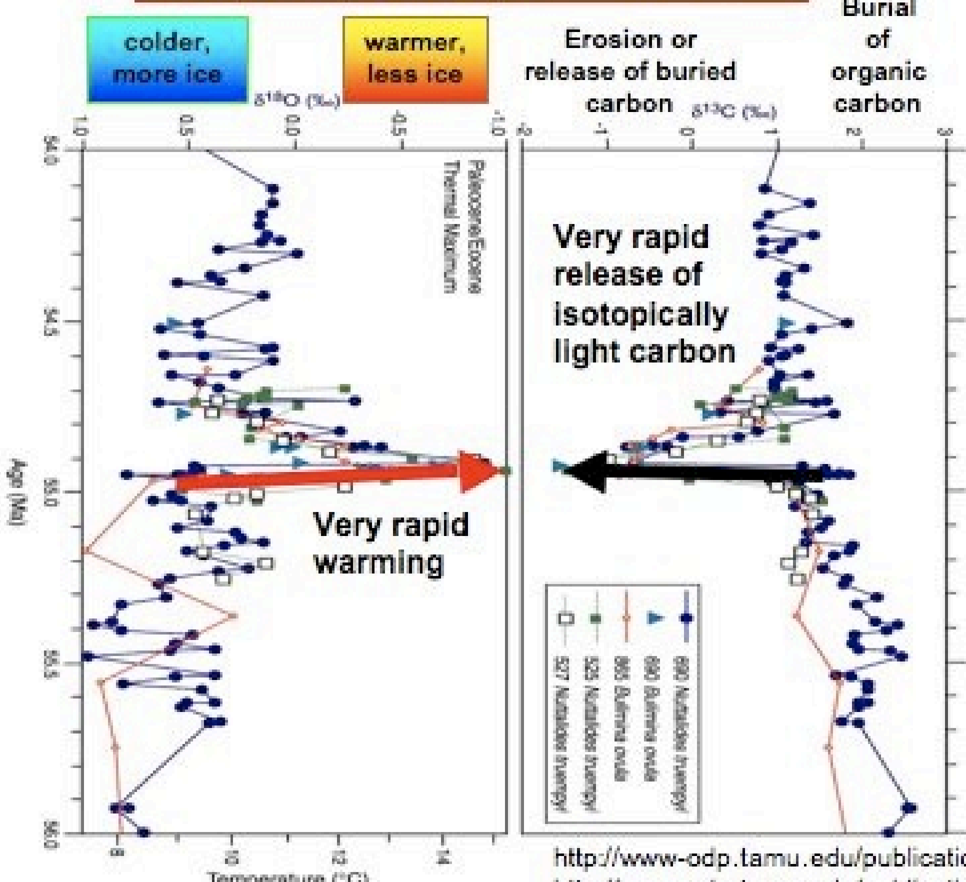
PETM (55 Ma): abrupt warming of 5-6°C (<10,000 years) and carbonate dissolution in the deep sea (ocean acidification); recovery 180-250 kyr.

<u>Note</u>: the rate of warming (0.5°C per 100 years) is very similar to the modern rate of global warming!

PETM in the northwest Pacific (transect of sites down Shatsky Rise)



Note: Stable isotopes of carbon ($\delta^{13}C$) are a good **proxy** for the **global carbon cycle**.

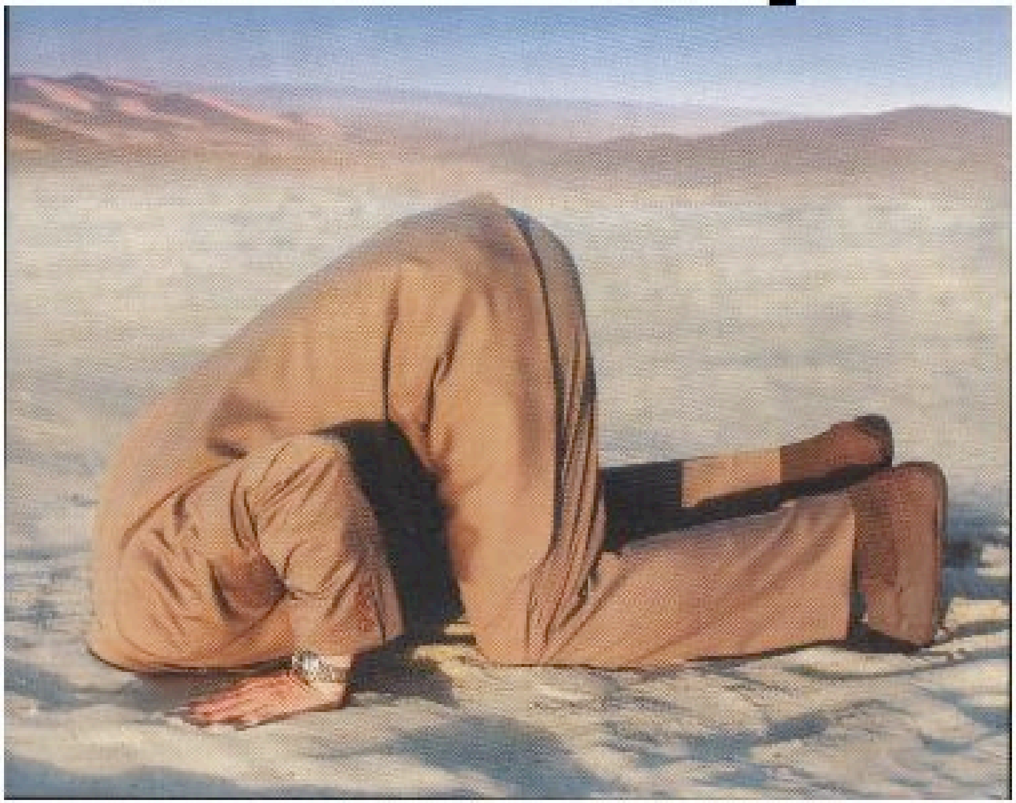


http://www-odp.tamu.edu/publications/198_IR/chap_01/c1_f53.htm#873593
http://www-odp.tamu.edu/publications/208_IR/chap_01/c1_f7.htm#1000493

Benthic foram isotope records across the P/E boundary from multiple deep sea sites (Zachos et al., 2001). **The Paleocene-Eocene Thermal Maximum** is characterized by an rapid **5-6°C warming** of the **deep sea** and **polar seas**. This event was likely triggered by the **rapid release of bacterially generated methane** in marine and terrestrial deposits associated with a longer-term interval of global warming.

This is an excellent example of the ocean-climate system being pushed to a critical **'threshold'** resulting in abrupt climate change.

Wake Up!

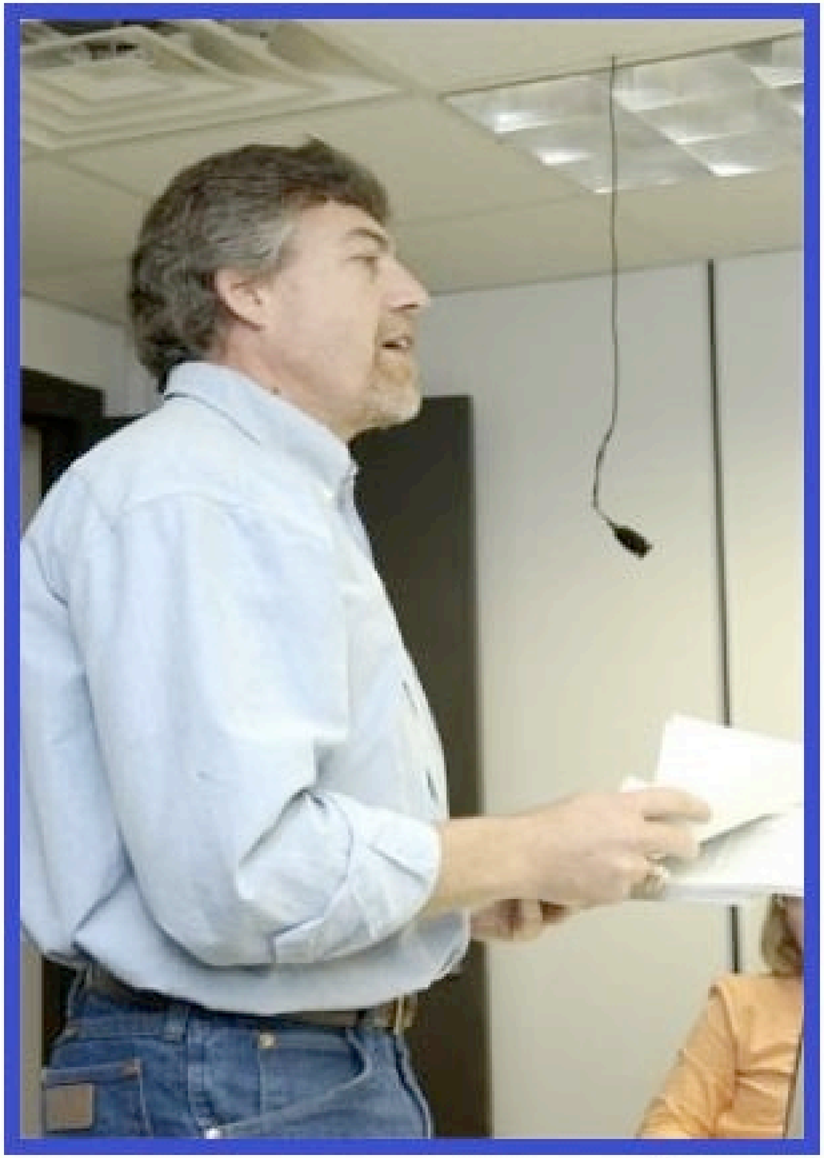


Will we accept the lessons of our recent geologic past? **The record is clear: polar regions are the most sensitive to greenhouse forcing.** *At what point will we aggressively act to slow global warming?*

There are many **compelling records of rapid climate change** preserved in ocean and lake sediments, fossil shells, ice cores, tree rings, corals, and speleothems.

All of these diverse **proxy data** (indirect evidence) clearly demonstrate that **our ocean-climate system can respond very abruptly** to various climate forcings, including greenhouse gases. ***Will the current pace of human activity trigger a "threshold event" that forces our climate into a new state?*** It's happened before and is very likely to happen again.

EXTRA SLIDES



Dr. Mark Leckie

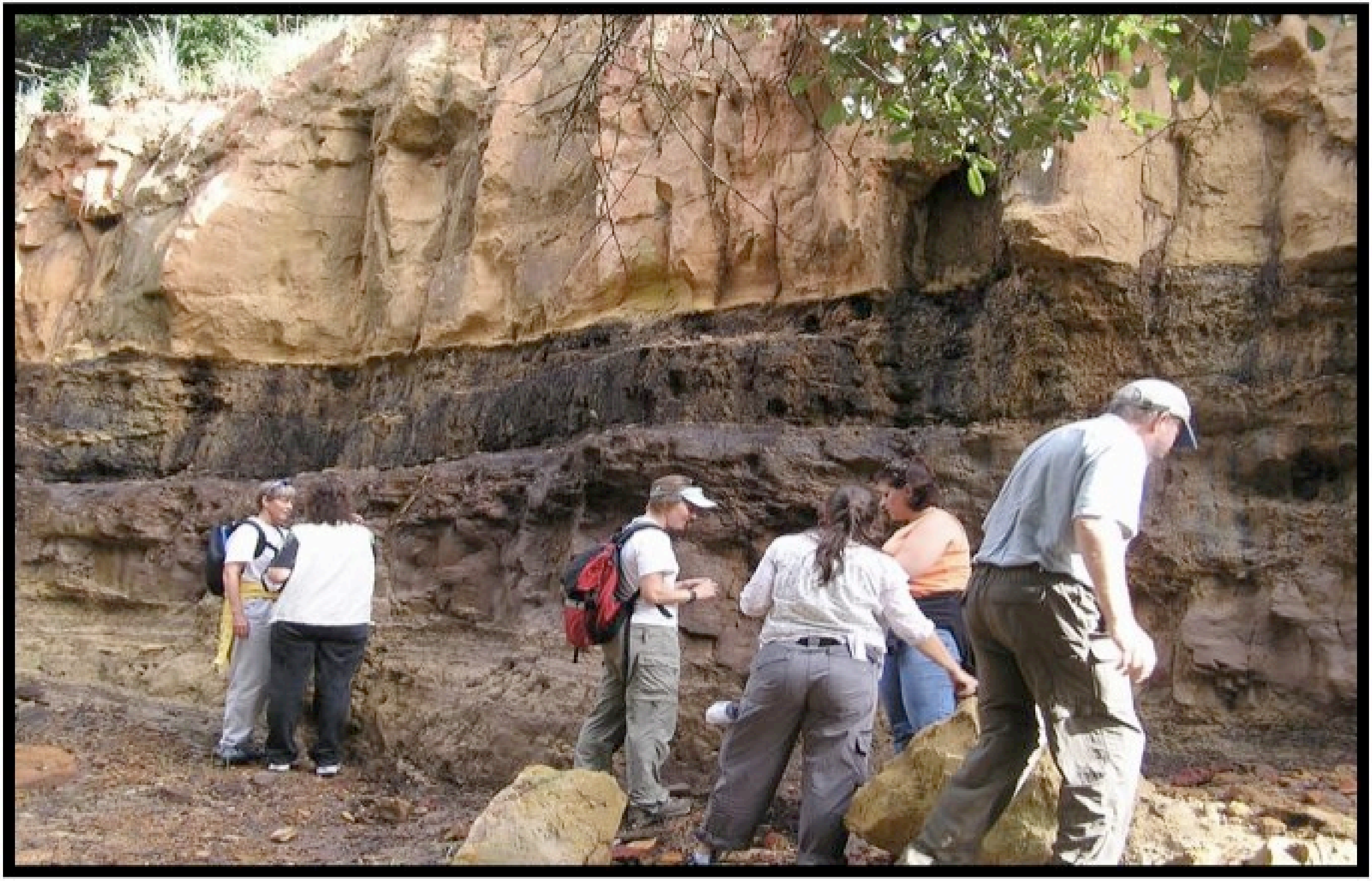
Department of Geosciences

University of Massachusetts at Amherst

- Oceanography
- Field Geology
- Micropaleontology
- Paleoceanography
- Biostratigraphy
- Paleoclimatology *and*

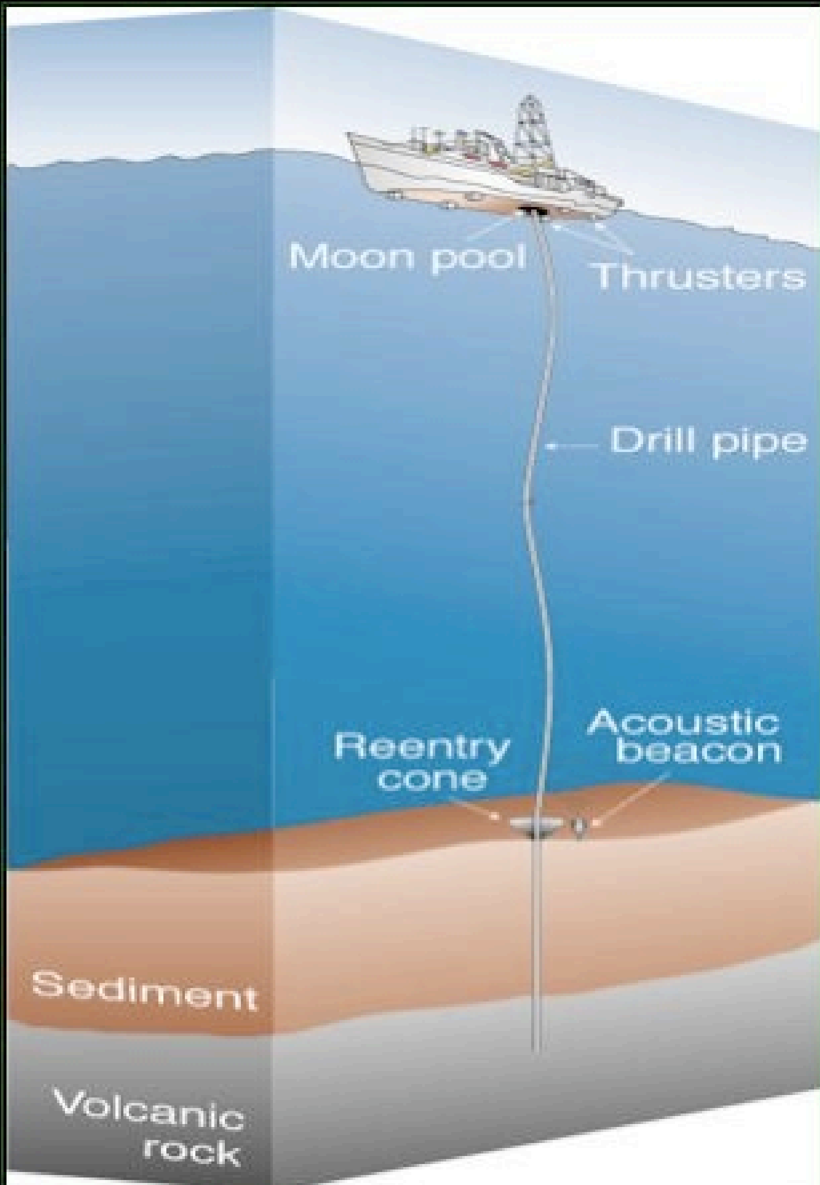
Research on tectonics and climate

Connecting Students to Authentic Research

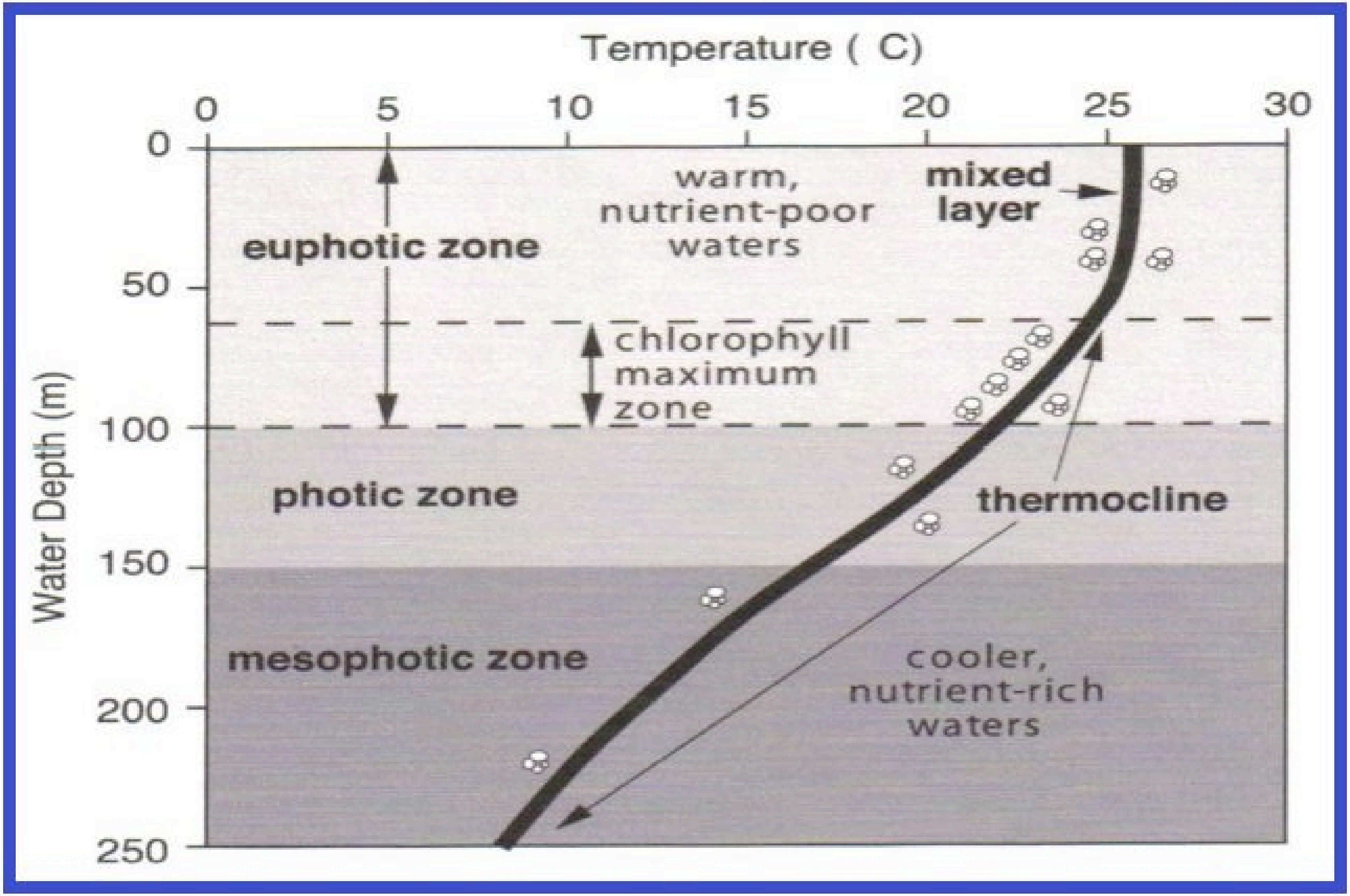


Reading the Environment... *Pages from the Past*

Re-entry into the Seafloor



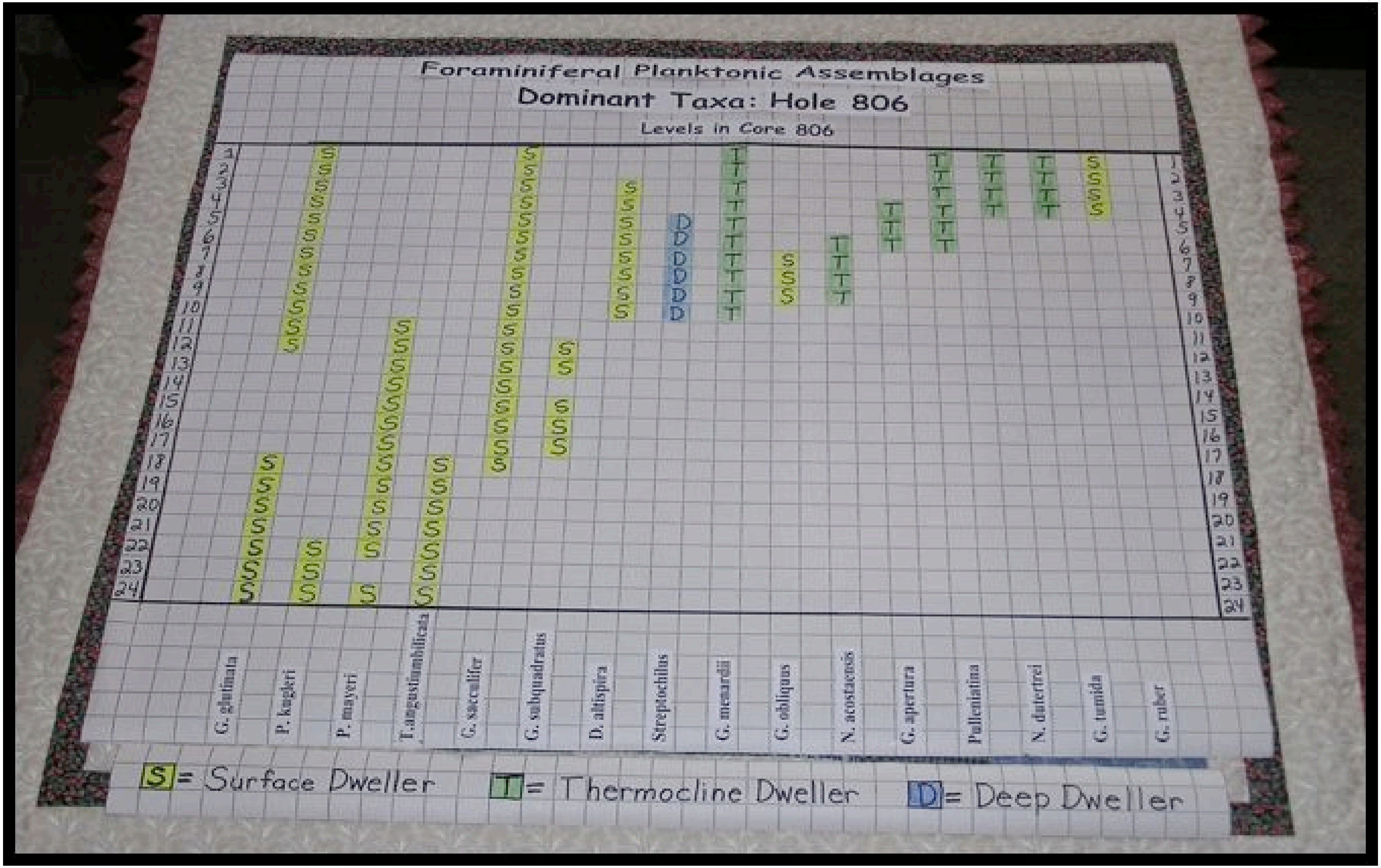
A Graphic from Dr. Leckie Introducing New Vocabulary



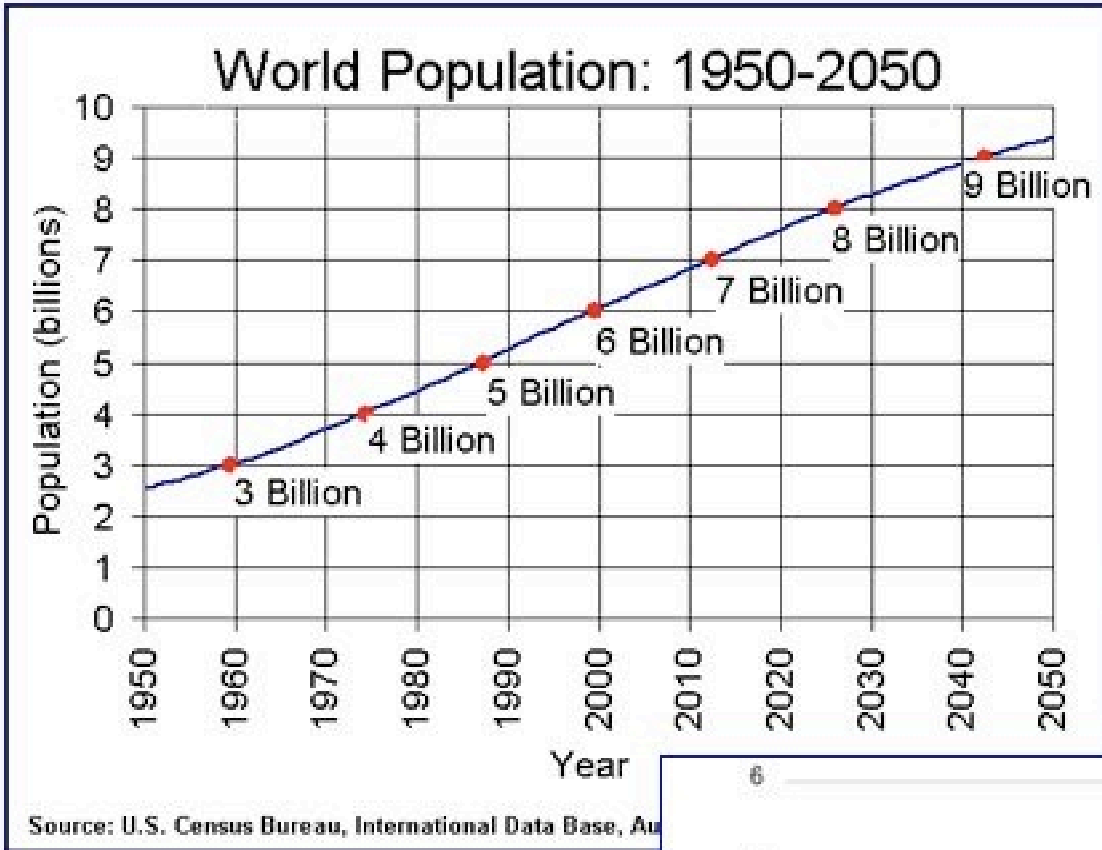
Cutting the Core into Workable Lengths (1.5 meter)

Learning to Interpret Sediment Cores from the Deep Ocean

Building the *Graphic Representation* by Sharing Data



Group Chart: Each student shared their section of data with the class.

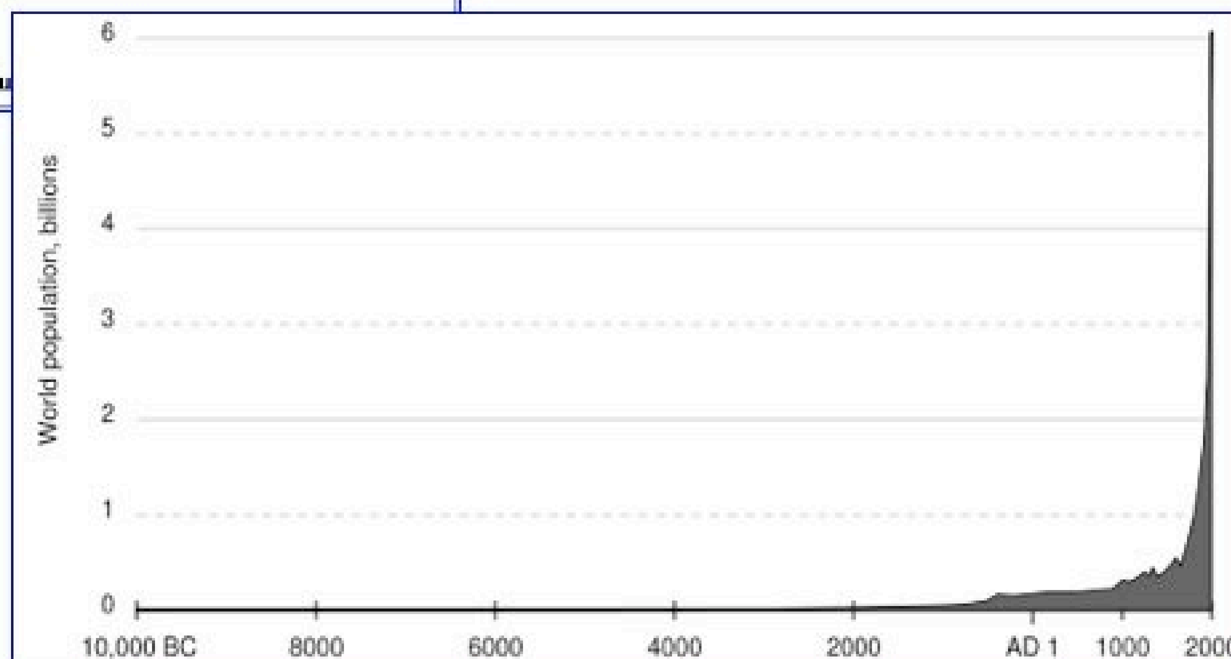


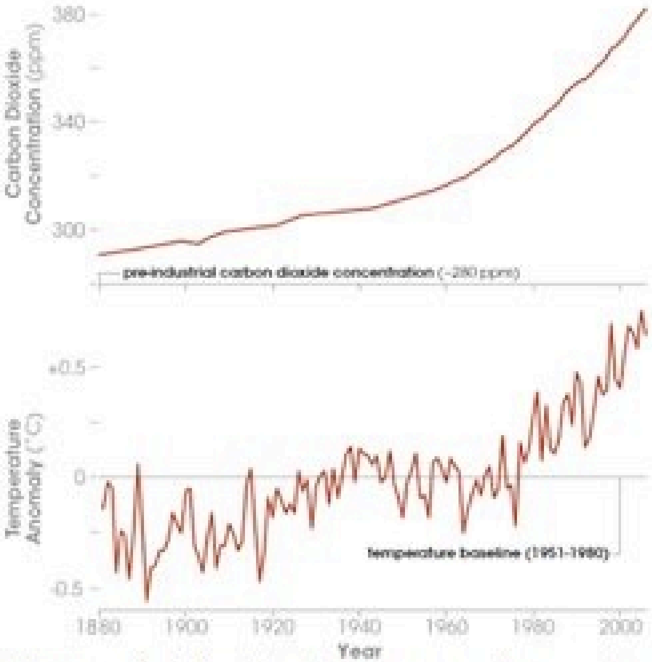
Past and future

95% of population growth is occurring in the developing world

http://www.census.gov/ipc/www/img/worldpop.gif

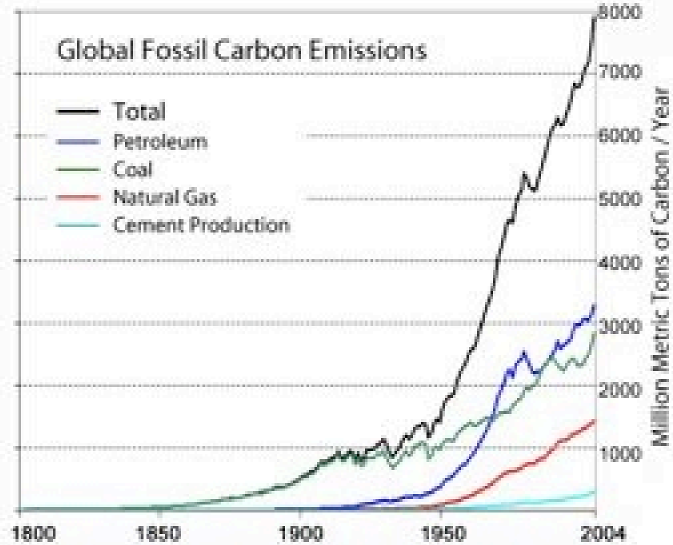
What is the human carrying capacity of our planet?



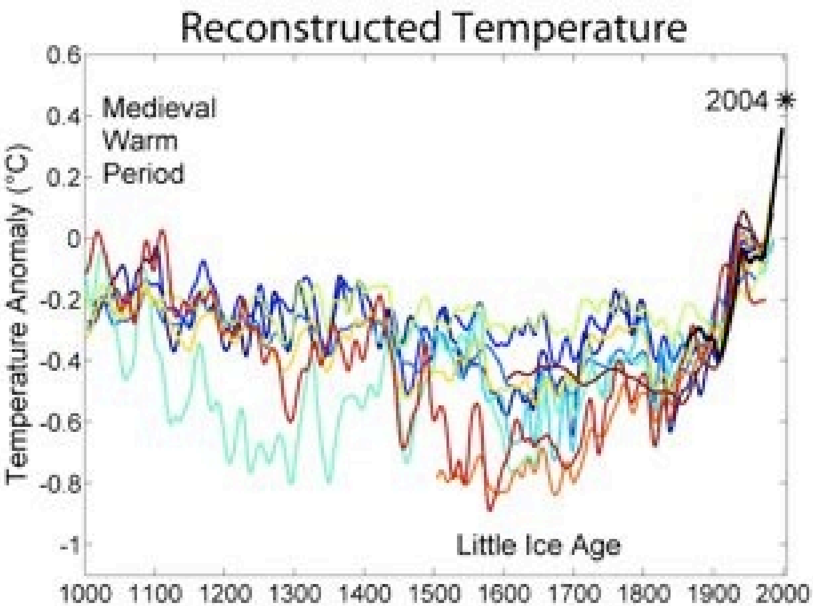


http://www.nrs.fs.fed.us/niacs/local-resources/images/nasa_graph.gif

Correlation does not imply causation, *but* ***do you notice any patterns in these data?***

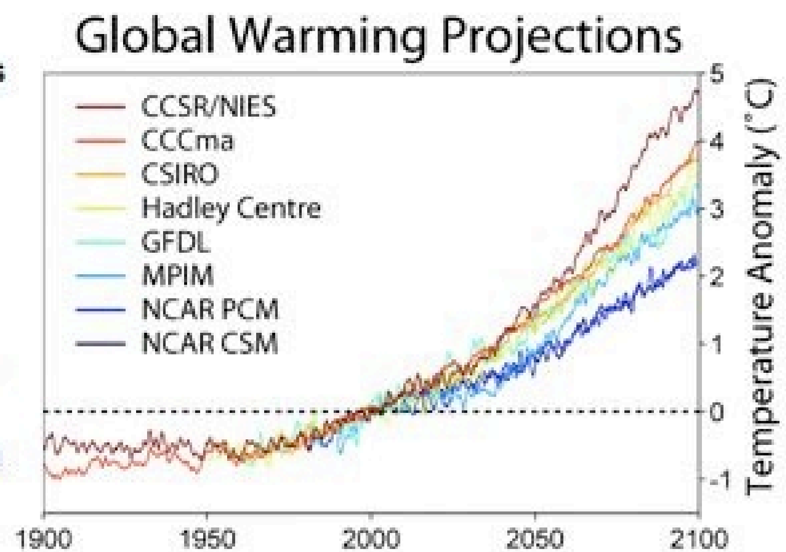


http://en.wikipedia.org/wiki/Greenhouse_gas

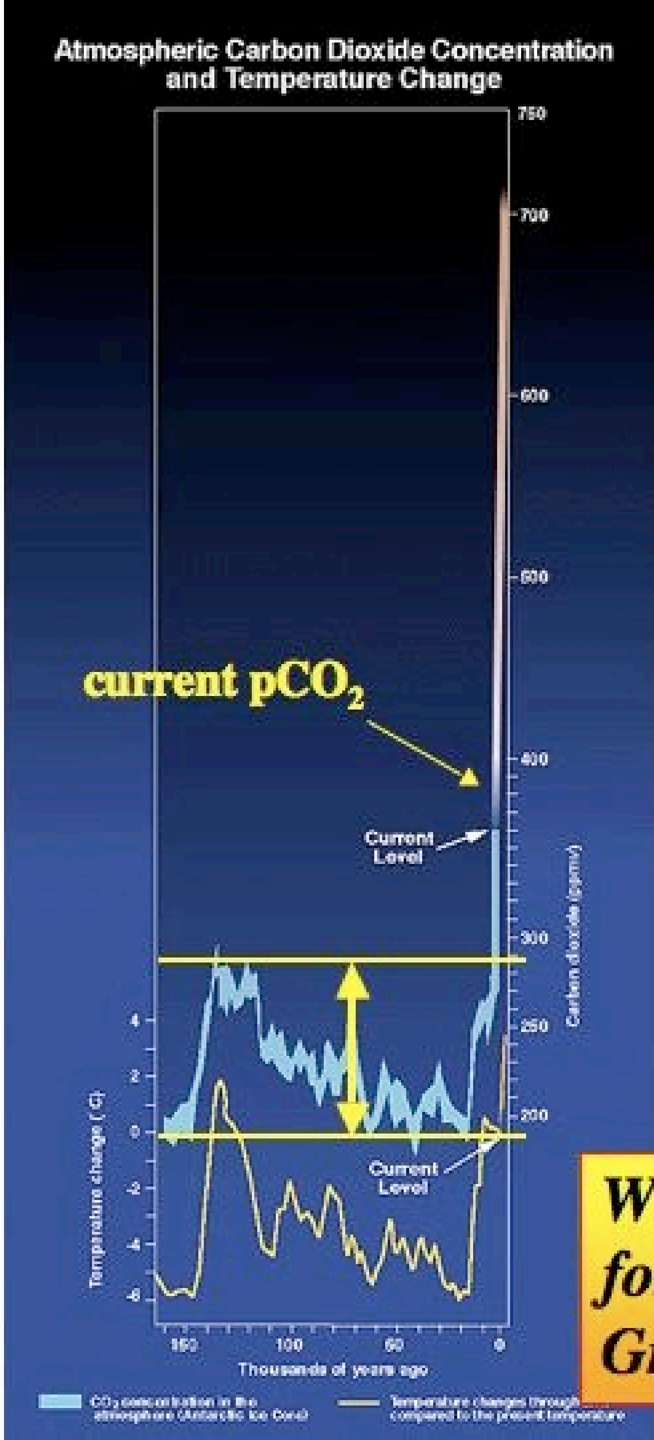


http://en.wikipedia.org/wiki/Hockey_stick_controversy

Reconstructions of Northern Hemisphere temperatures for the last 1,000 years according to various older articles (bluish lines), newer articles (reddish lines), and **instrumental record (black line).**



http://en.wikipedia.org/wiki/File:Global_Warming_Predictions.png

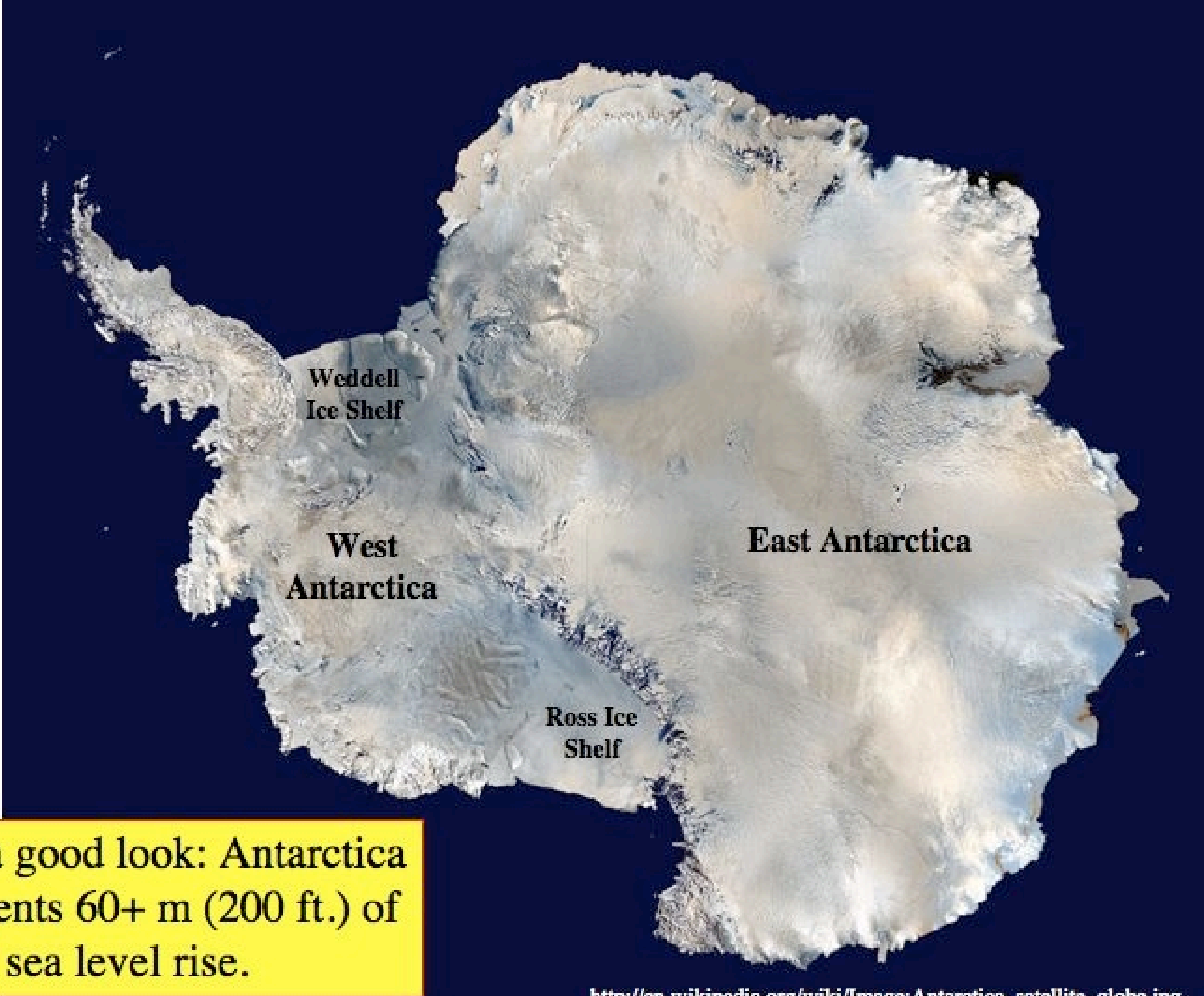


Where will it peak?

Talking points:

1. Global **temperatures track pCO_2** through glacial-interglacial cycles.
2. The **natural range of pCO_2 variability** is ~190-290 ppm.
3. Atmospheric **pCO_2 has been steadily rising** since the onset of the industrial revolution in the mid-1800's.
4. We have greatly **exceeded the natural range** of pCO_2 variability; **<u>human activity has unequivocally altered the composition of our atmosphere</u>**.

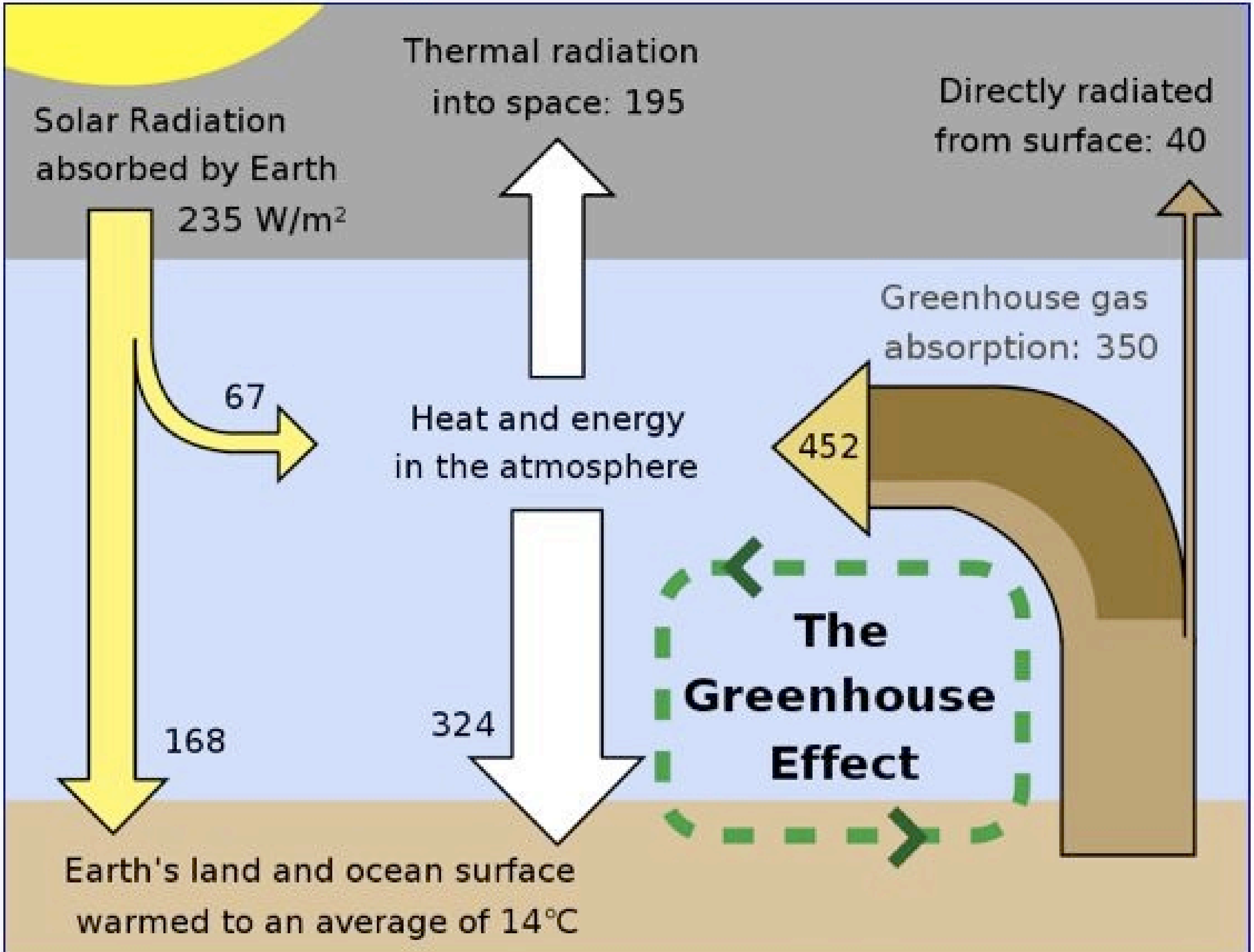
When will we 'get it'? What is the threshold for global action? Catastrophic collapse of the Greenland and/or W. Antarctic ice sheet?



Take a good look: Antarctica represents 60+ m (200 ft.) of global sea level rise.

http://en.wikipedia.org/wiki/Image:Antarctica_satellite_globe.jpg

The Greenhouse Effect and Global Warming



http://en.wikipedia.org/wiki/File:Greenhouse_Effect.svg

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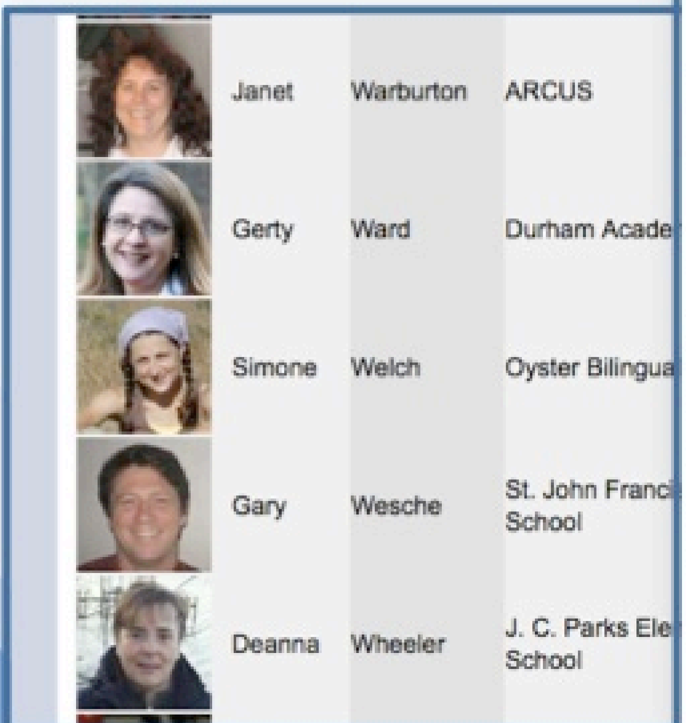

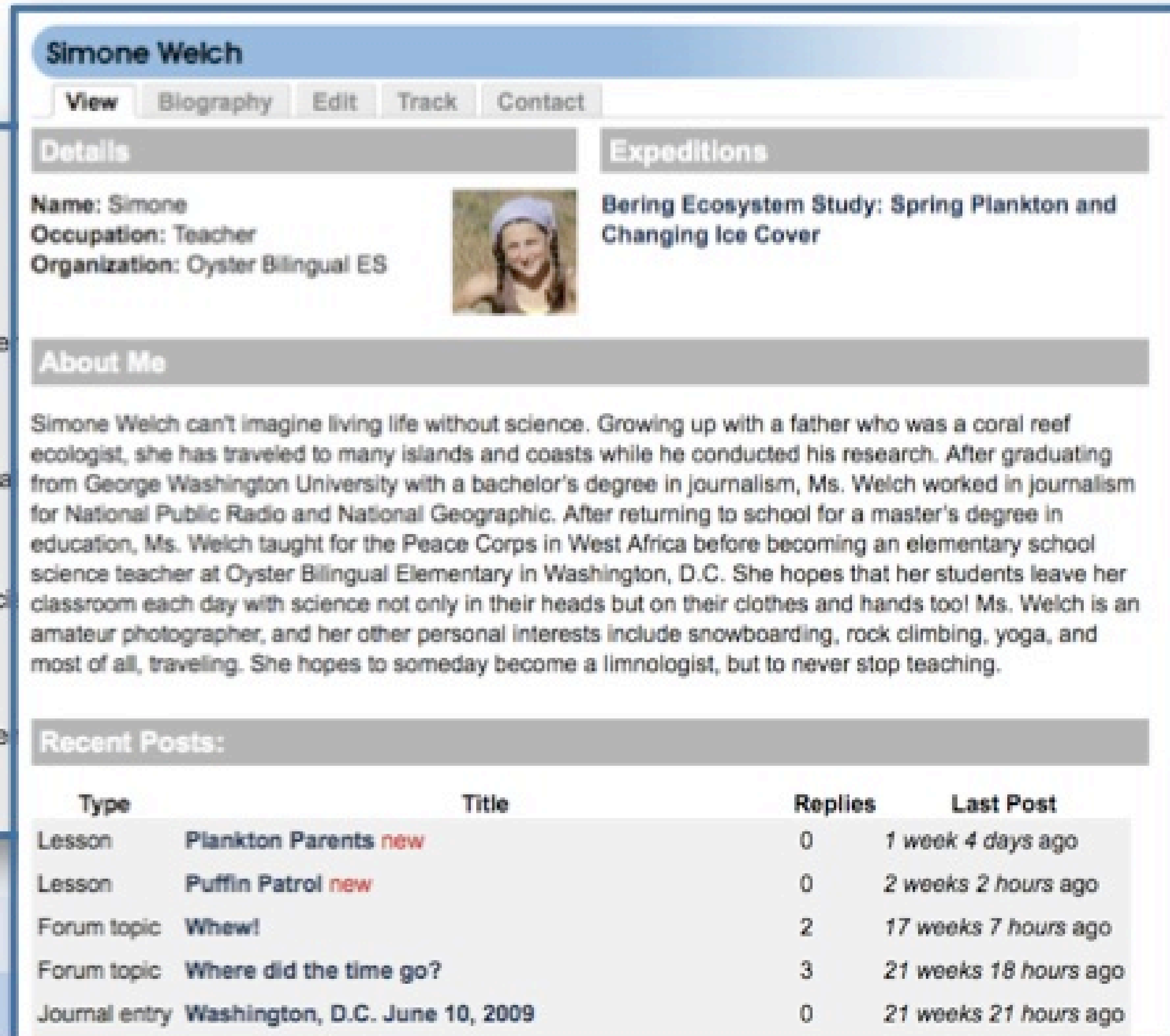

Thank You

- Join us for upcoming events!
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