Today...

- Our experiment, continued.
- Finish up “cell size” discussion.
- Asymptotics (approximations when x is small or large)

  - Reminder: OSH 1 due Monday!
  - Reminder: Pre-lecture 2.1 due Monday!
  - Reminder: Assignment 1 due Thursday!

Learning experiment

- Experiment - write your name, where you were born and what you plan to major in on a piece of paper and pass it to someone you don't know sitting near you.
- Read the info and try to remember it. Give the paper back to your neighbour.

Nutrient balance in a spherical cell

- Absorption is proportional to surface area:

$$S = 4\pi r^2 \qquad A = k_1 S = 4k_1 \pi r^2$$

- Consumption is proportional to volume:

$$V = \frac{4}{3}\pi r^3 \qquad C = k_2 V = \frac{4}{3}k_2 \pi r^3$$

where k_1 and k_2 are positive constants.

Which of the following is true?

$$C = \frac{4}{3} k_2 \pi r^3 \qquad A = 4 k_1 \pi r^2$$

(A) Absorption is greater than consumption for sufficiently large cells and vice versa for small cells.

(B) Consumption is greater than absorption for sufficiently large cells and vice versa for small cells.

(C) Both A and B are possible - it depends on k_1 and k_2 .

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Back to the experiment

- Left side of room - show your piece of paper to your neighbour and let them read over it again.
- Right side of room - do not show your neighbour the paper again but ask them to repeat the info as best they can. After they do so, show them the paper.

Power functions

- A function of the form $f(x) = ax^n$ (where *a* is a constant and *n* is an integer) is called a power function.
- Both $C = \frac{4}{3}k_2\pi r^3$ and $A = 4k_1\pi r^2$ are power functions (with r as independent variable).

$$C(r) = \left(\frac{4}{3}k_2\pi\right) r^3 \qquad A(r) = (4k_1\pi)\, r^2$$

Power functions

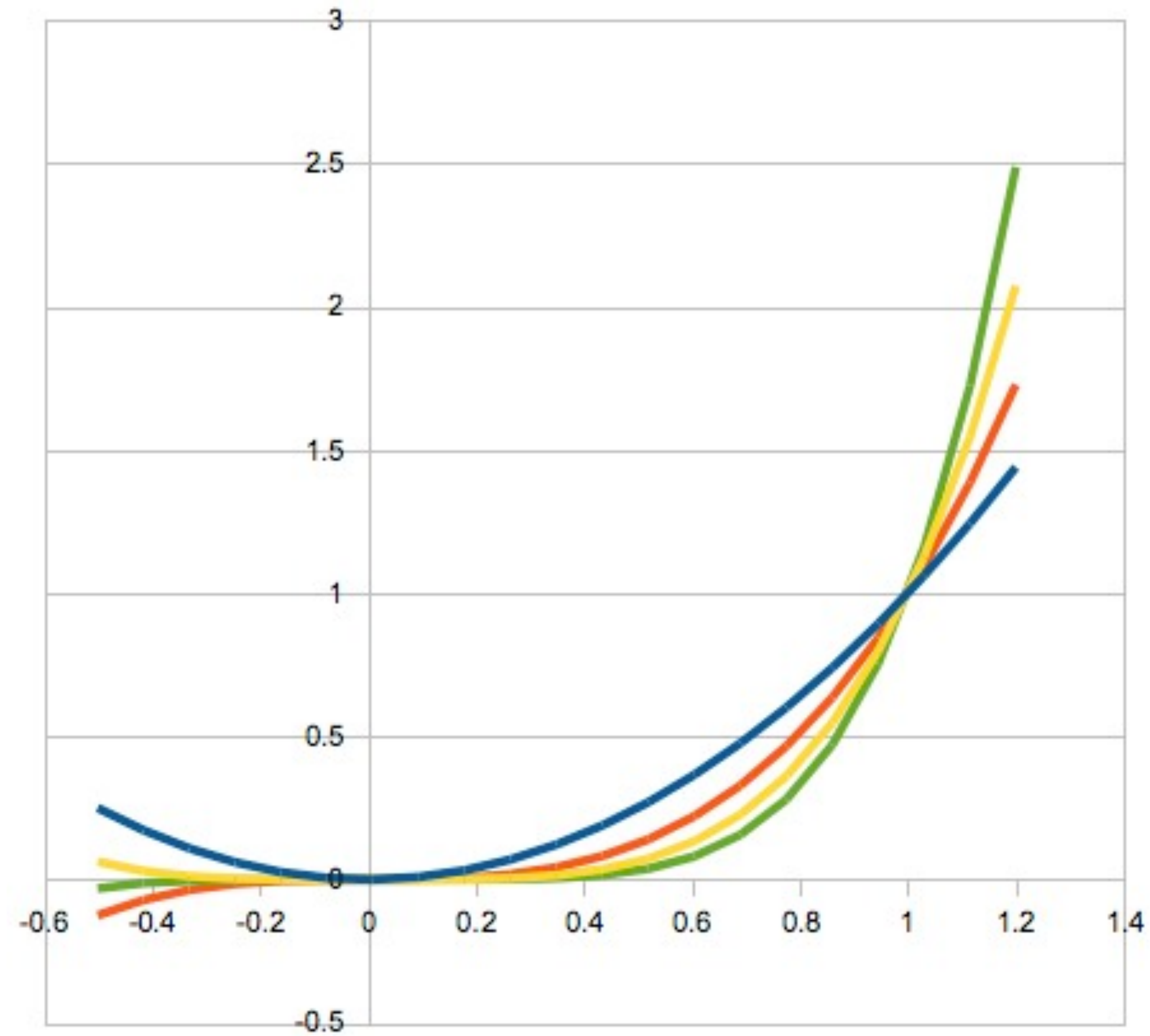
(A) Green: x^3, yellow: x^4, red: x^5, blue: x^6.

(B) Green: x^5, yellow: x^4, red: x^3, blue: x^2.

(C) Green: x^6, yellow: x^5, red: x^4, blue: x^3.

(D) Either (B) or (C) (not enough info).

(E) Don't know - please explain.



Power functions

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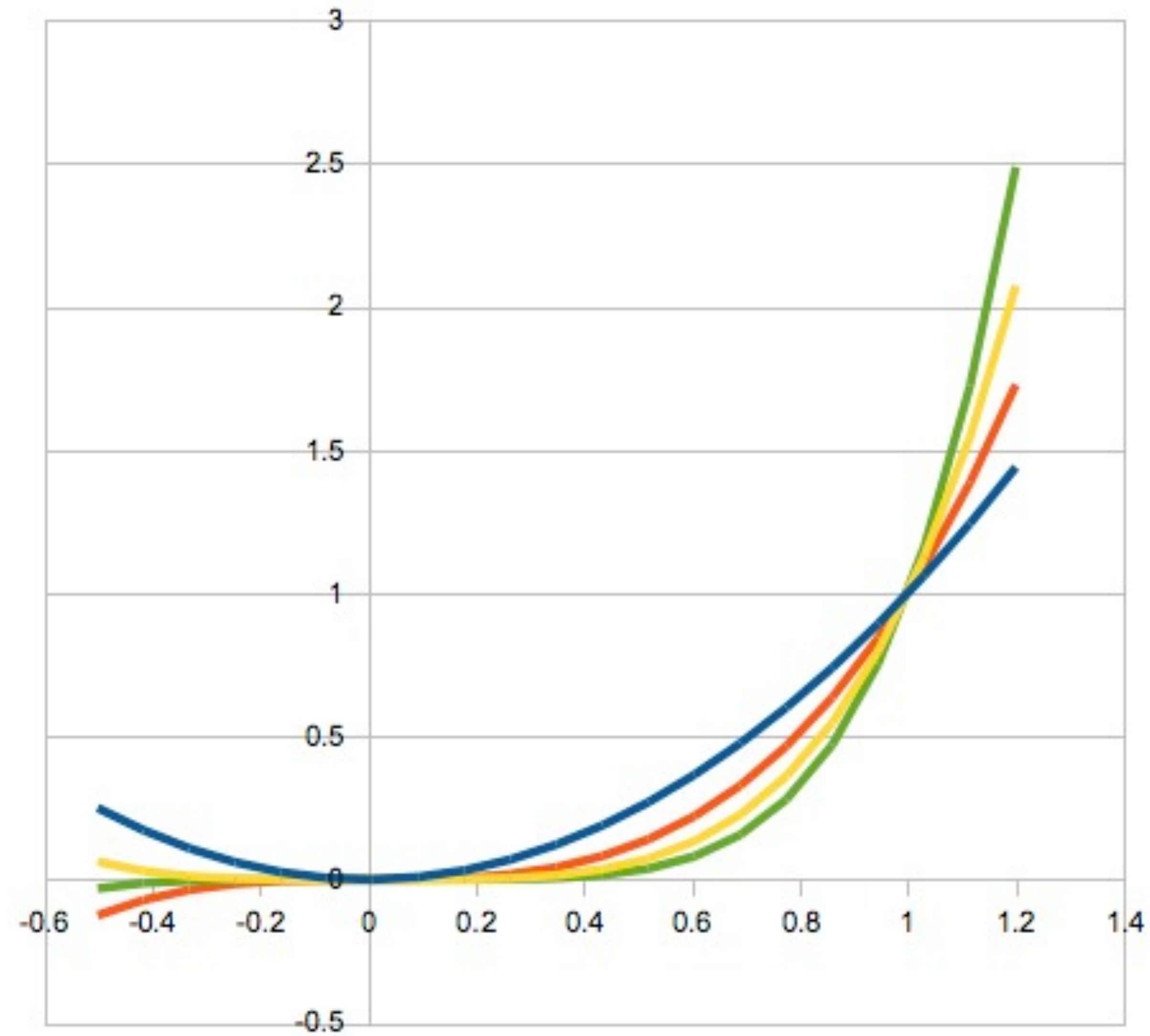


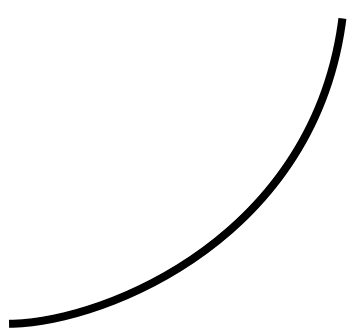
Limit on cell size

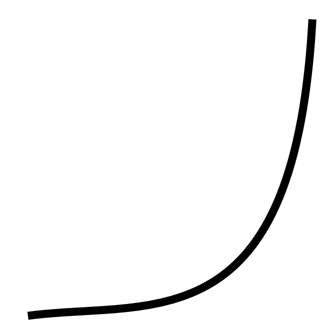
- When is absorption > consumption?

stretch r^2 vertically

stretch r^3 vertically

$$A = 4k_1\pi r^2 > \frac{4}{3}k_2\pi r^3 = C$$





- Solve for r in terms of other parameters:

$$r < 3\frac{k_1}{k_2}.$$

Back to the experiment

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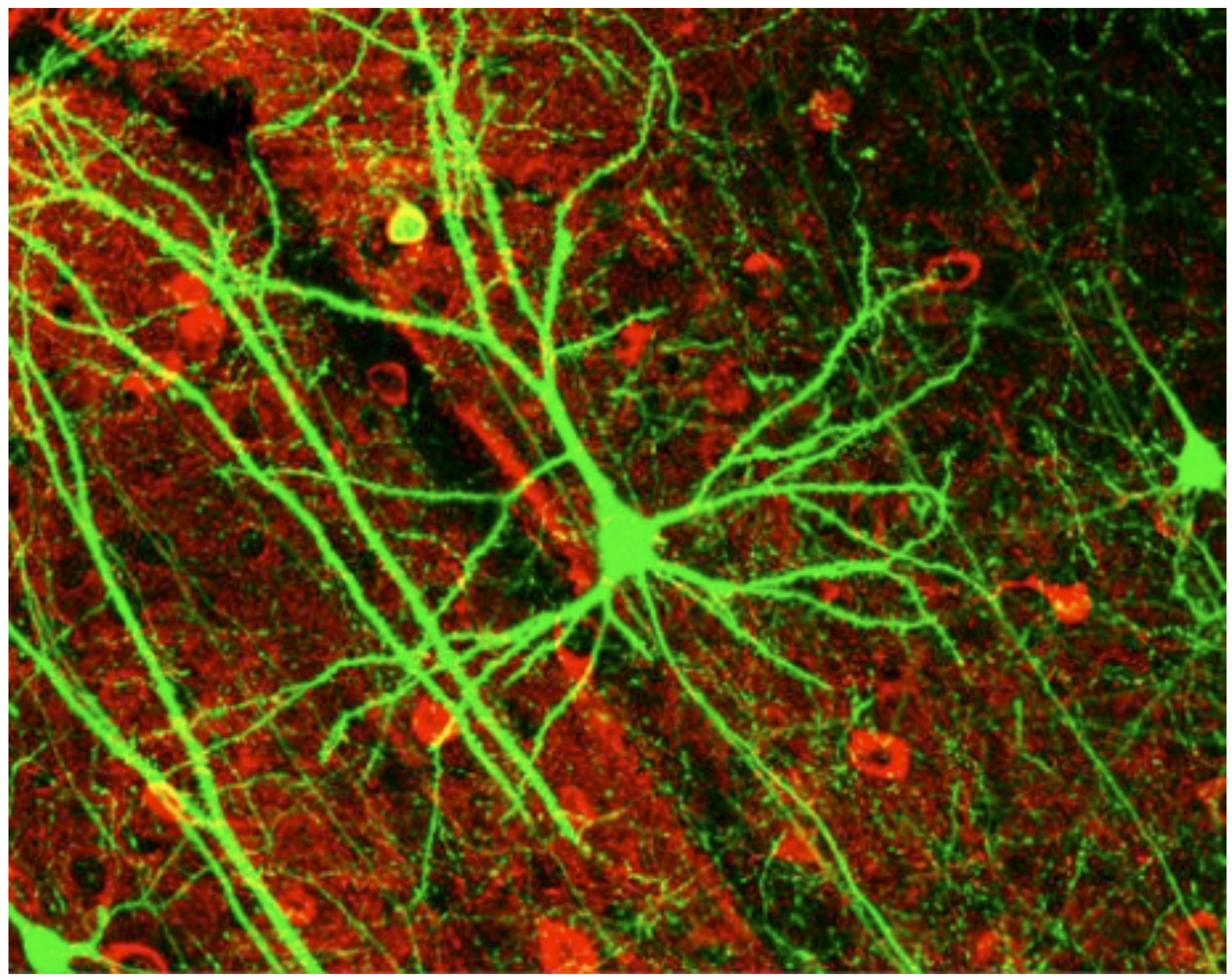
The “biggest” cells around



Neuron (1 meter)

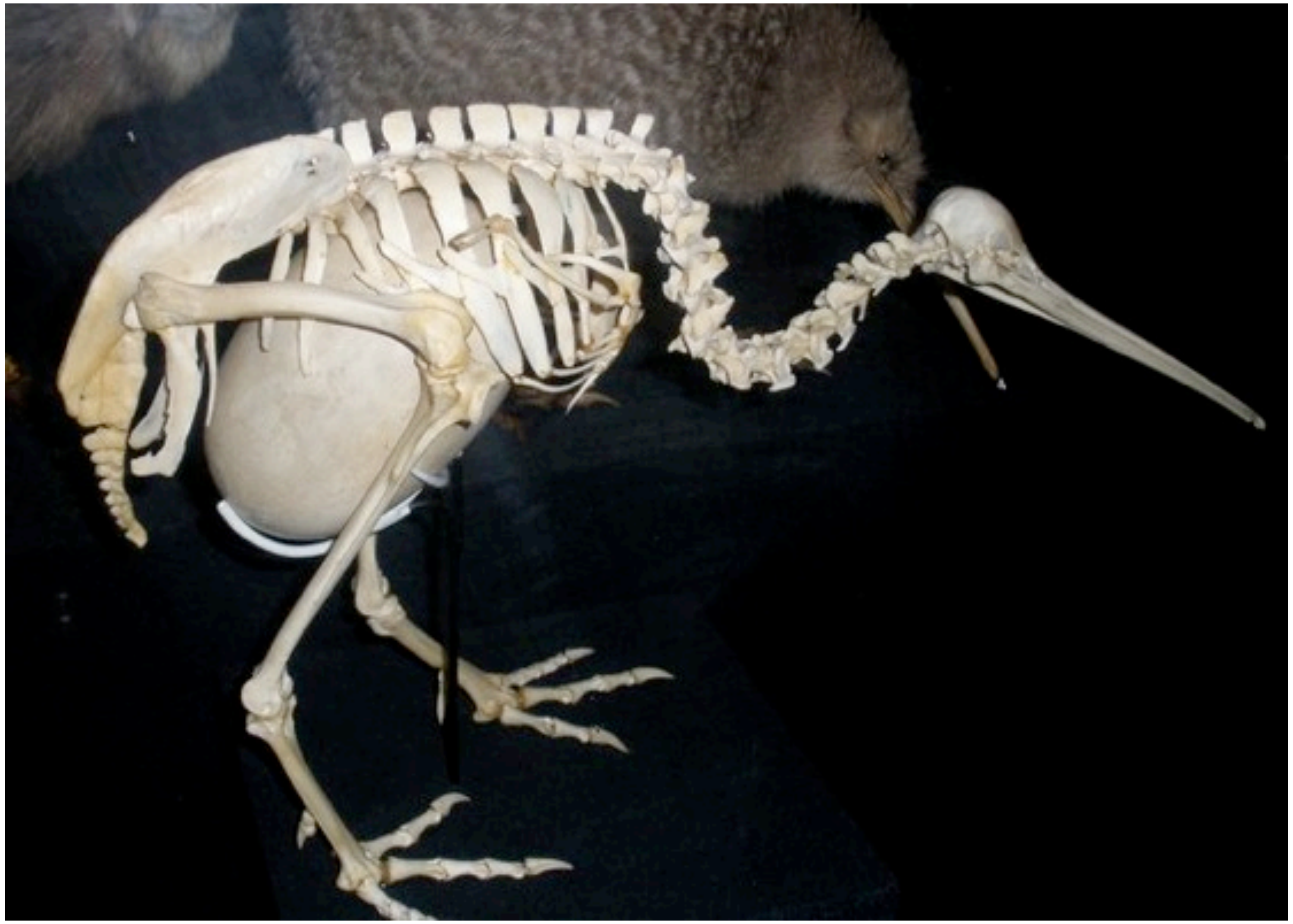
The “biggest” cells around

Caulerpa prolifera (single cell, 1 meter)

Getting around S:V issues

- Don’t be spherical if you want to be big.

“Exceptions”



Kiwi egg (not the biggest but remarkable)

“Exceptions”

Ostrich egg

Extra - How does this cell get around the S:V issue?

Back to the experiment

- Both sides of room - do not show your neighbour the paper again but ask them to repeat the info as best they can. After they do so, show them the paper.

(A) All 3 pieces of information correct.

(B) Only 2 pieces of information correct.

(C) Only 1 piece of information correct.

(D) Nothing correct.

Back to the experiment

- Retrieval is critical for memory/learning.
- Reading notes or watching a lecture not as good as actively accessing.
- Interleaving versus blocking.
- “Desirable difficulties” improve long term recall.
- If a method of learning feels easier - be skeptical that it’s better!

Asymptotics - approximations when x is small or large

- 0.001 is only small compared to something like 1.
- Compared to 0.0000001, it's big.
- Small and big are relative.
- It's only "safe" to ignore something "small" when it's being added to something big.
- Sometimes use notation $0.001 << 1$.

Comparisons and approximation must be based on relative sizes!

For each of the following, (A) True, (B) False, (C) Not sure. . .
You line up some bricks to make a wall one brick high.

- The wall is small ($a \approx 0$).
- If you make the wall 20 times as high, it is still small ($20a \approx 0$).
- Add one row of bricks to a wall 20 bricks high. The new wall is about the same size as the old wall. ($a+b \approx b$)

Comparisons and approximation must be based on relative sizes!

Fo .

Yo

- Th
- If 0)). ds.
- Ac is ab

When $x << 2$, then $x + 2$ can be approximated by...

(A) 2

(B) x

(C) infinity

(D) Don’t know - please explain.

(Assume $x>0$.)

When $x << 2$, then $x + 2$ can be approximated by...

(A) 2

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(C) infinity

(D) Don’t know - please explain.

(Assume $x>0$.)

When $x \gg b$, then $x + b$ can be approximated by...

(A) b

(B) x

(C) infinity

(D) Don’t know - please explain.

(Assume x, b are positive.)

When $x >> b$, then $x + b$ can be approximated by...

(A) b

(B) x

(C) infinity

(D) Don’t know - please explain.

(Assume x, b are positive.)

When $|x| \ll 1$, then $x^2 - x^3$ can be approximated by...

(A) x^2

(B) $-x^3$

(C) None of the above.

(D) Don't know - please explain.

When $|x| << 1$, then $x^2 - x^3$ can be approximated by...

(A) x^2

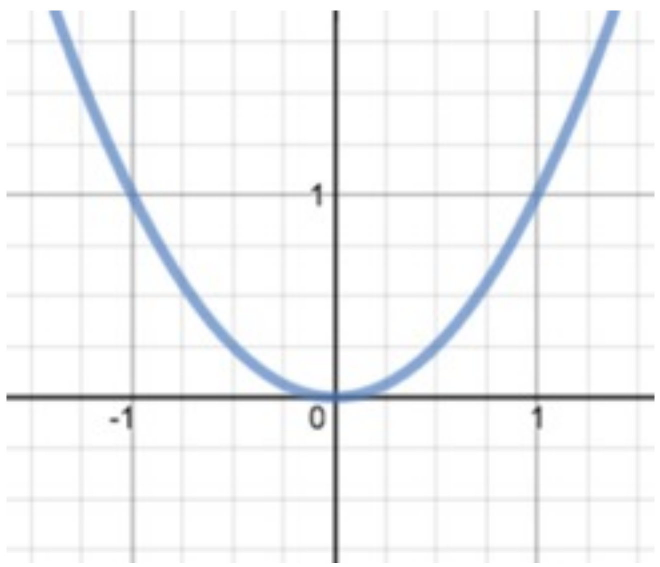
(B) $-x^3$

(C) None of the above.

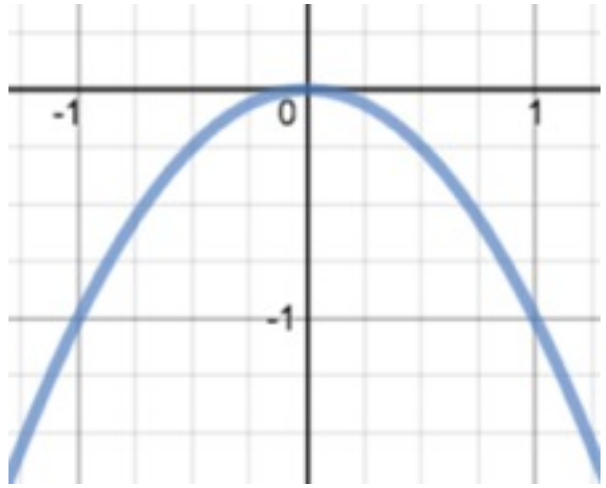
(D) Don't know - please explain.

Which of the following provides a good approximation to the graph of $f(x)= x^2 - x^3$ near the origin?

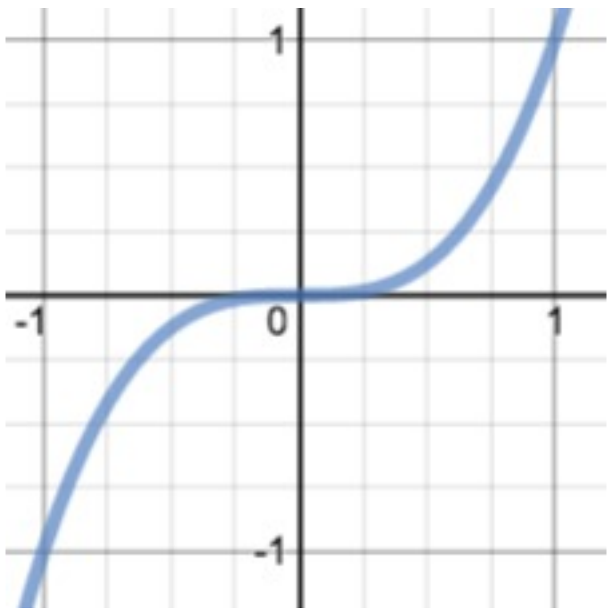
(A)



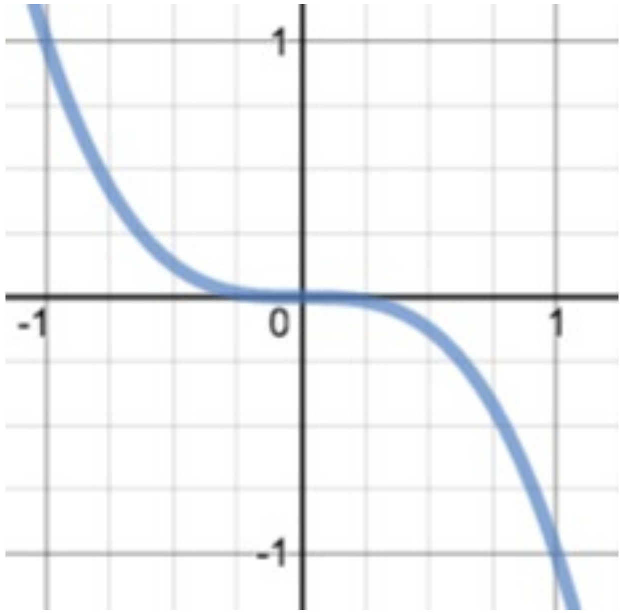
(B)



(C)



(D)



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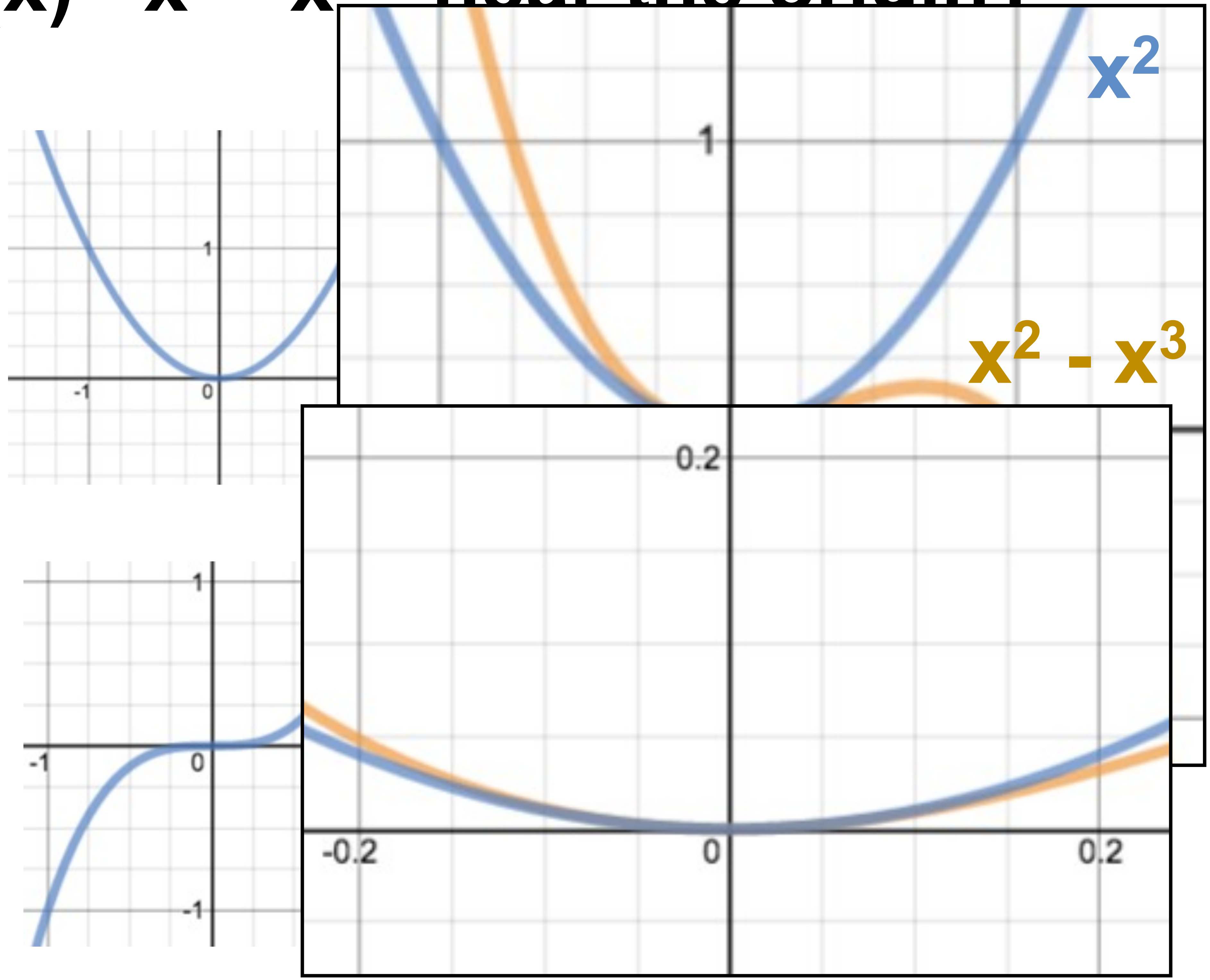


(C)

When $|x| \gg 1$, then $x^2 - x^3$ can be approximated by...

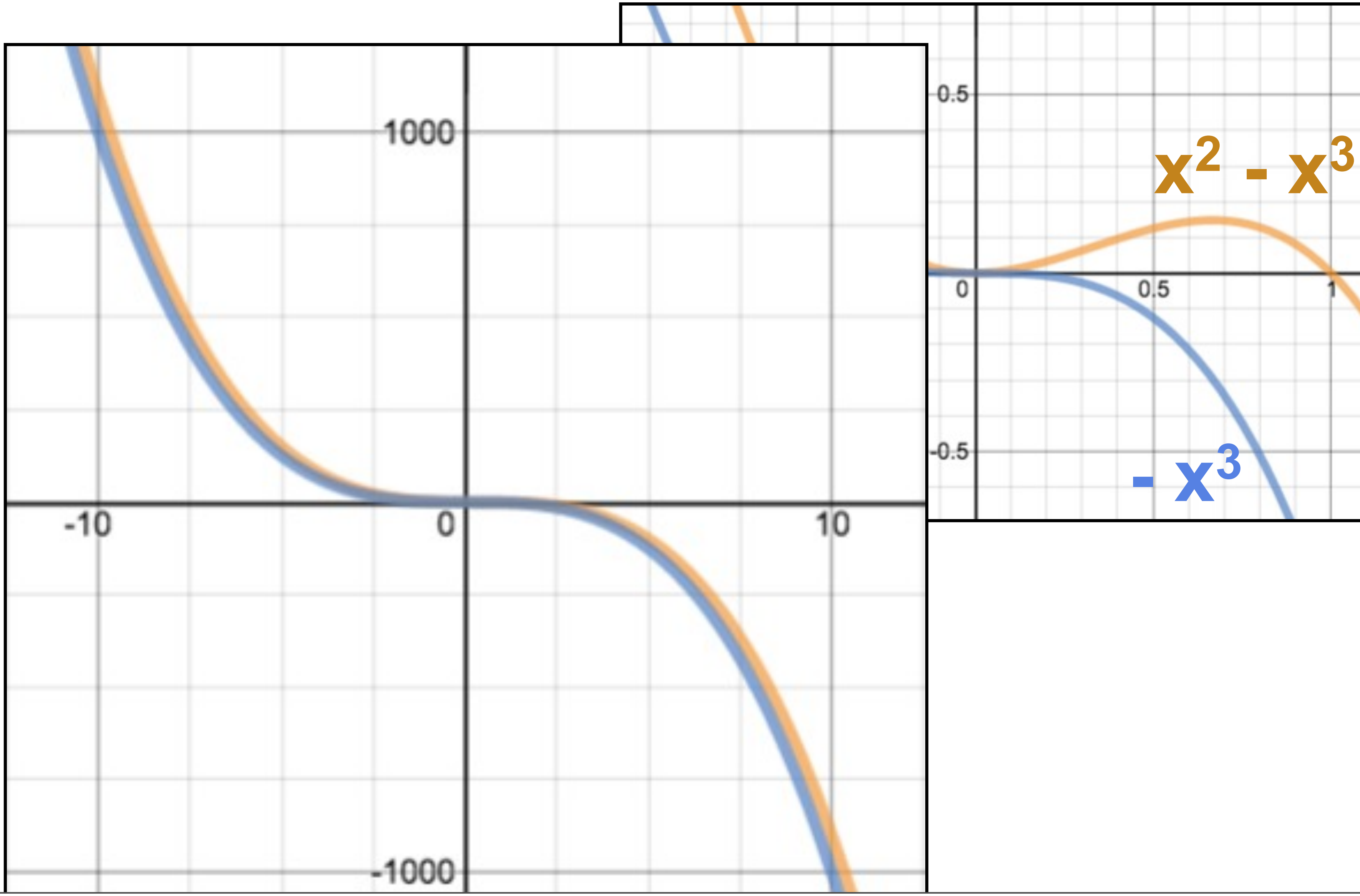
(A) x^2

(B) $-x^3$

(C) None of the above.

(D) Don't know - please explain.

When $|x| >> 1$, then $x^2 - x^3$ can be approximated by...



Coming up next lecture

- Hill functions - a family of rational functions that comes up in many models in biology.
  - Using asymptotics to understand their shape.
  - Sketching them.