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

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Power functions

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

Power functions

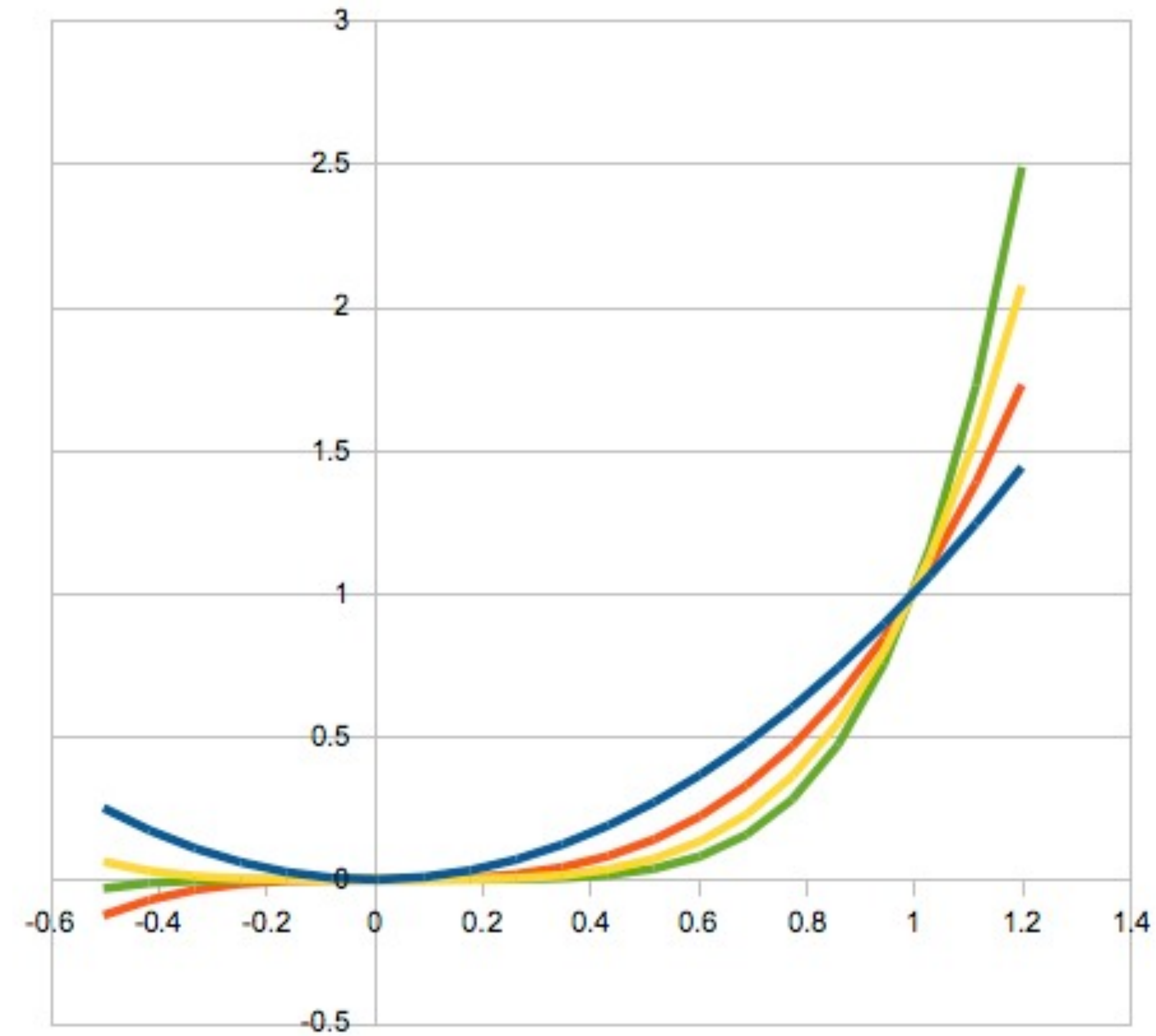
(A) Green: x^3, yellow: x^4, red: x^5, blue: x^6.

(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.



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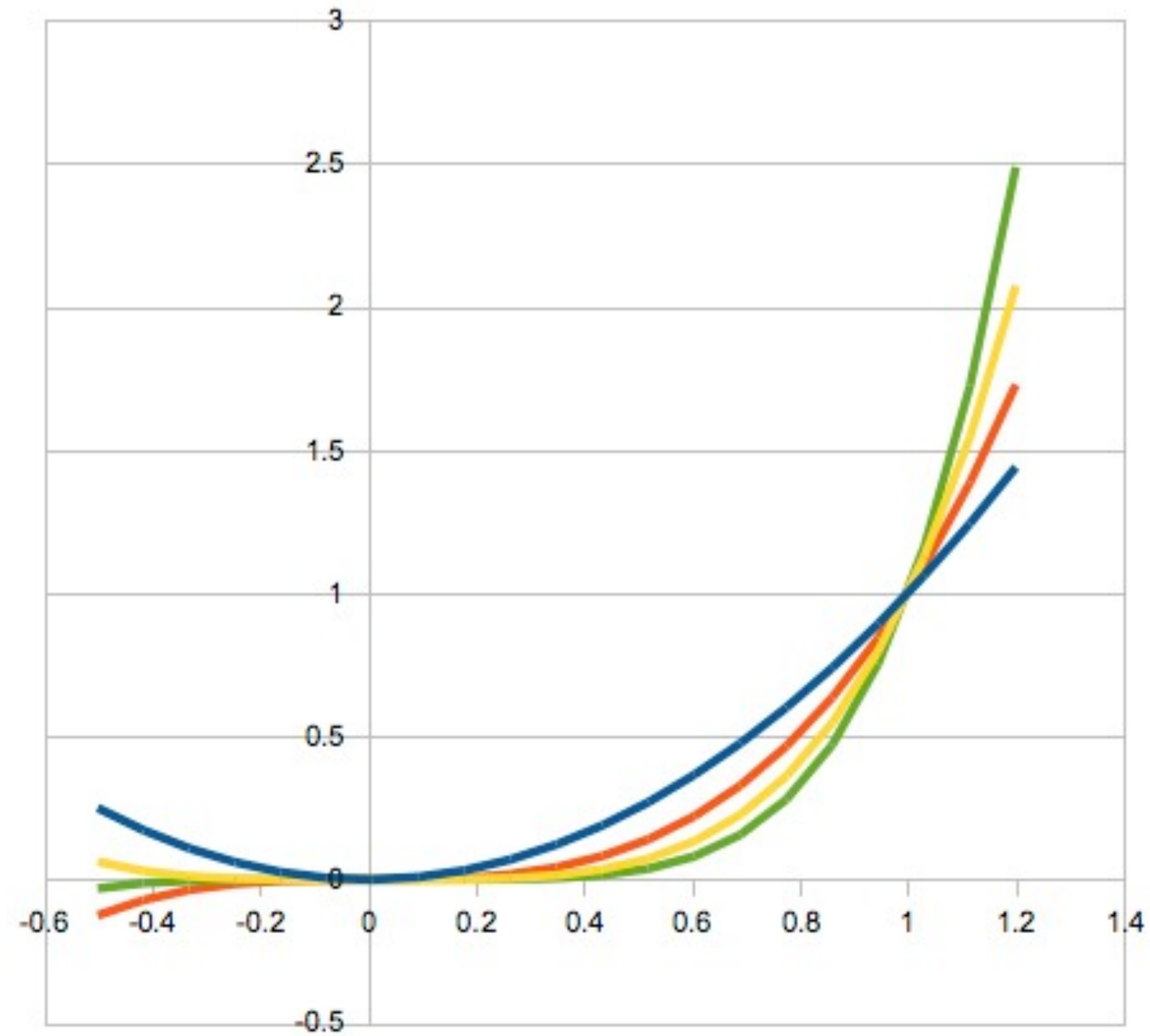

Limit on cell size

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- When is absorption > consumption?

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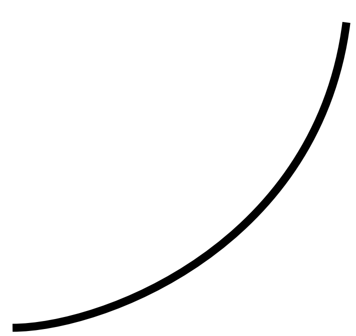

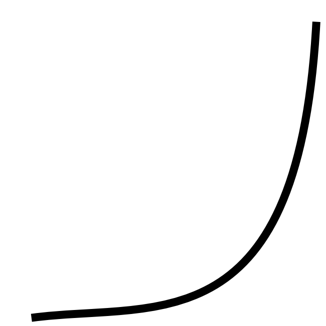

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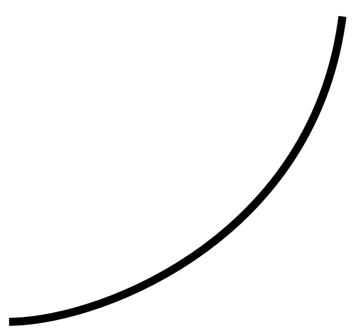

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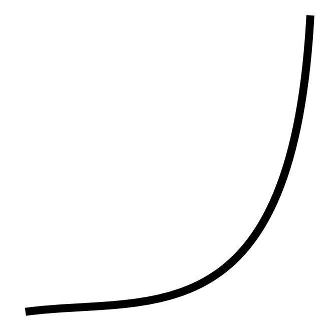

- Solve for r in terms of other parameters:

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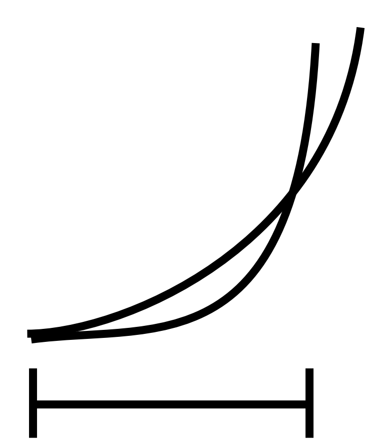
- Solve for r in terms of other parameters:

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



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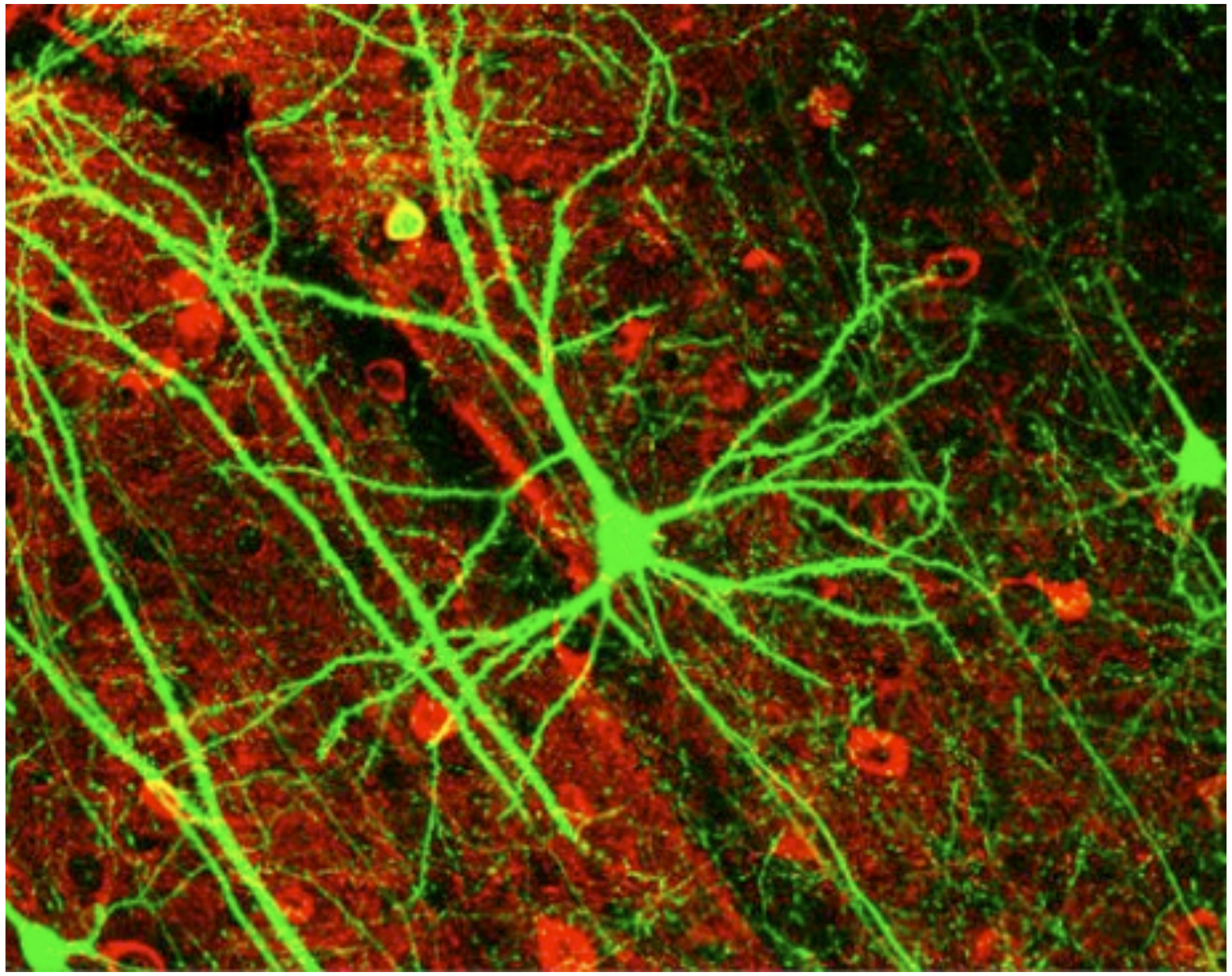
The “biggest” cells around



Neuron (1 meter)

The “biggest” cells around

Caulerpa prolifera (single cell, 1 meter)

Getting around S:V issues

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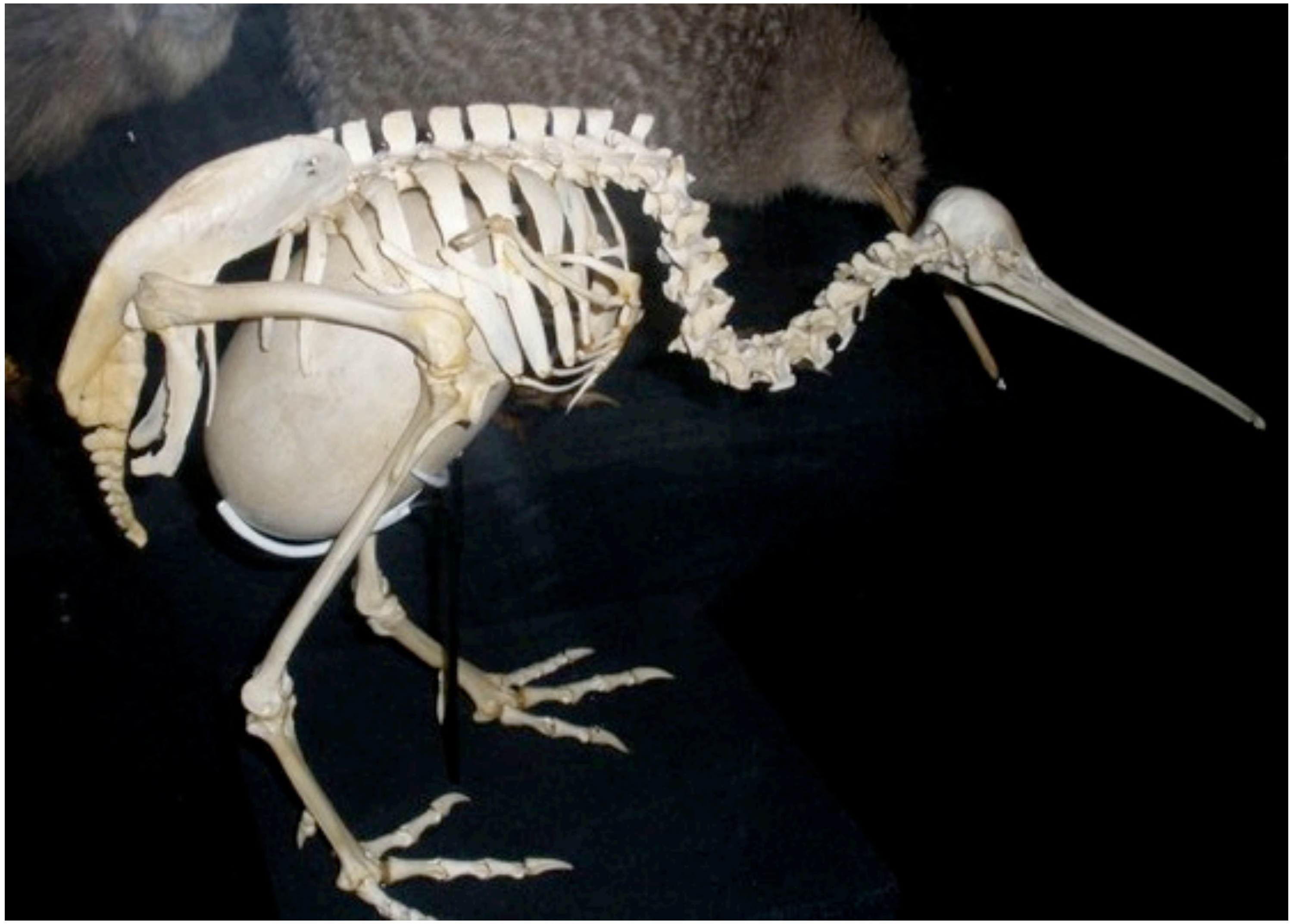
- Don’t be spherical if you want to be big.

“Exceptions”



Kiwi egg (not the biggest
but remarkable)

"Exceptions"

Ostrich egg

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

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(A) All 3 pieces of information correct.

(B) Only 2 pieces of information correct.

(C) Only 1 piece of information correct.

(D) Nothing correct.

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- “Desirable difficulties” improve long term recall.

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- 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

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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 ($a \approx 0$).

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Yo … k high.

- Th
- If … small (20a ≈ 0).
- Ac … The new wall is
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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 $x \ll 2$, then $x + 2$ can be approximated by...

(A) 2

(B) x

(C) infinity

(D) Don't know - please explain.

(Assume $x>0$.)

When $x \gg b$, 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) $-x^3$

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

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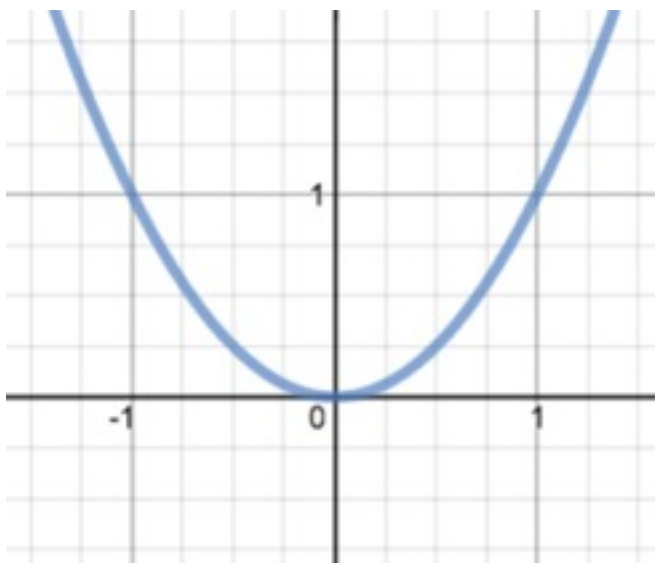

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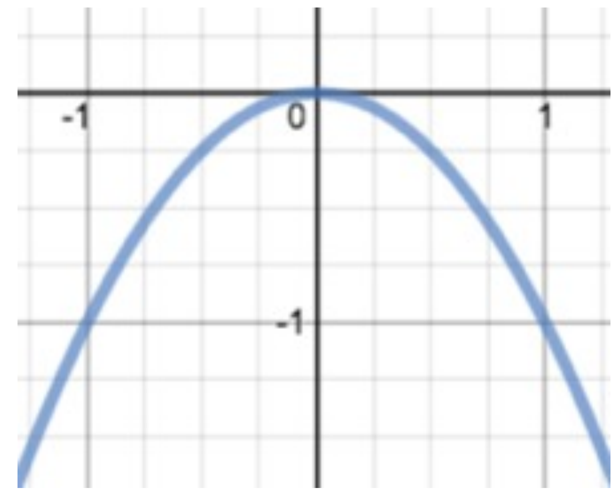
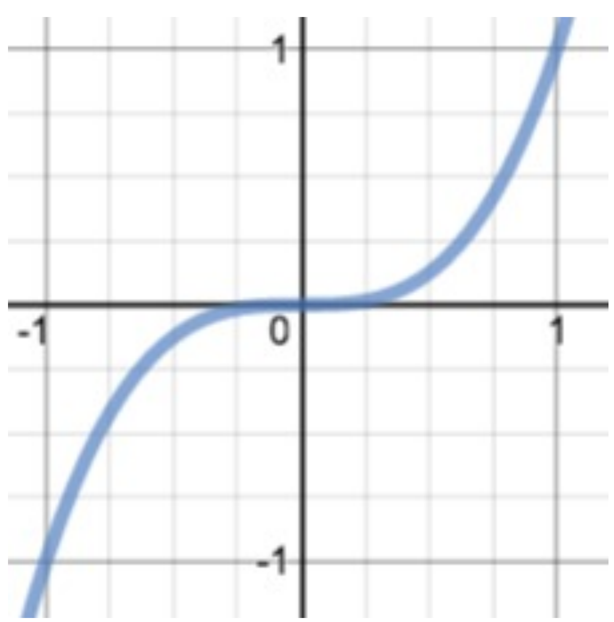
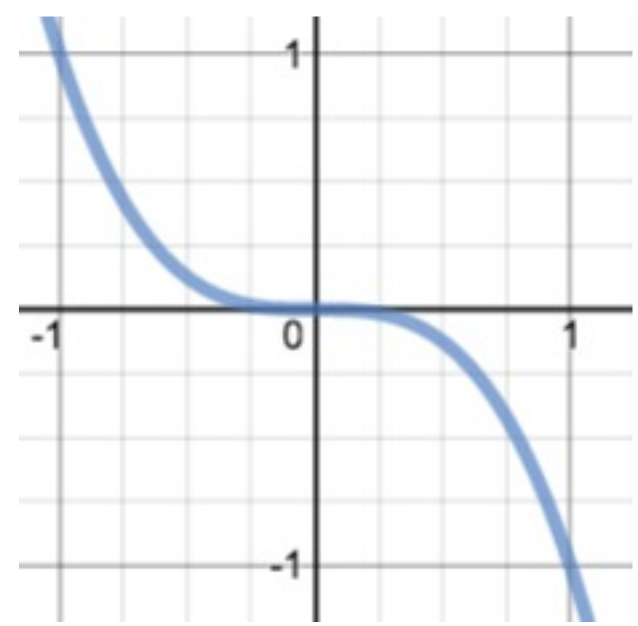


(C)



(D)



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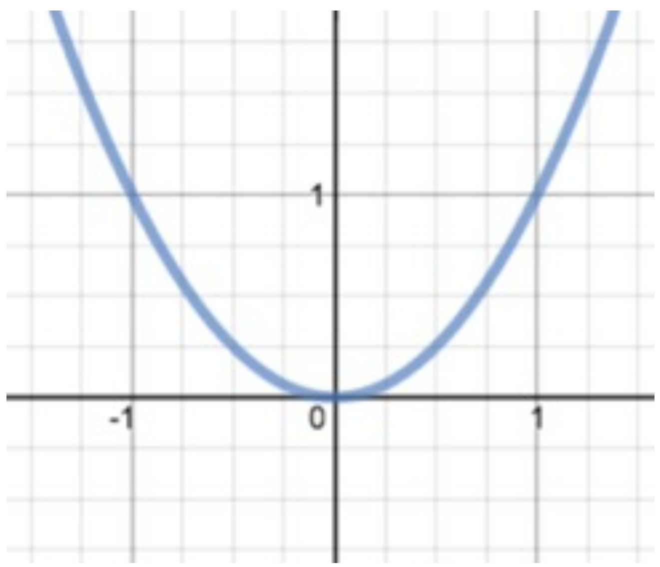

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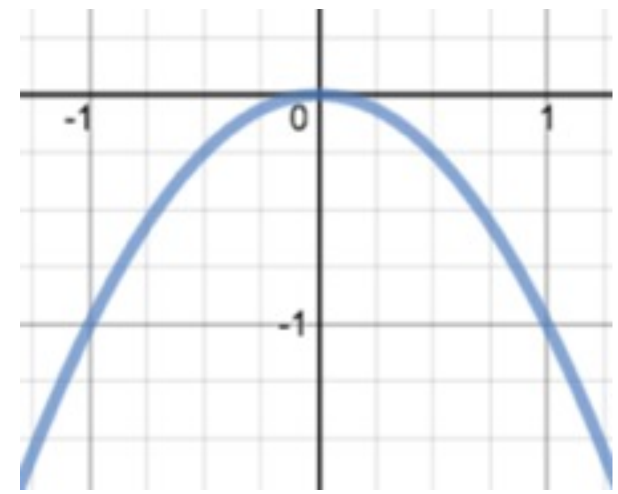

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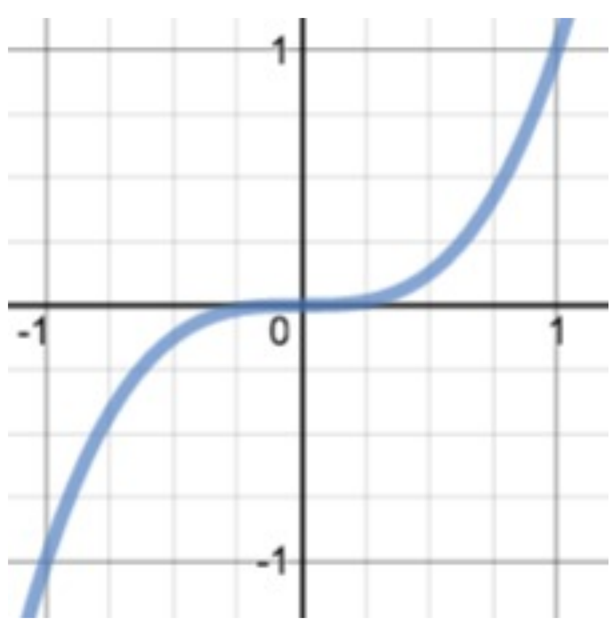

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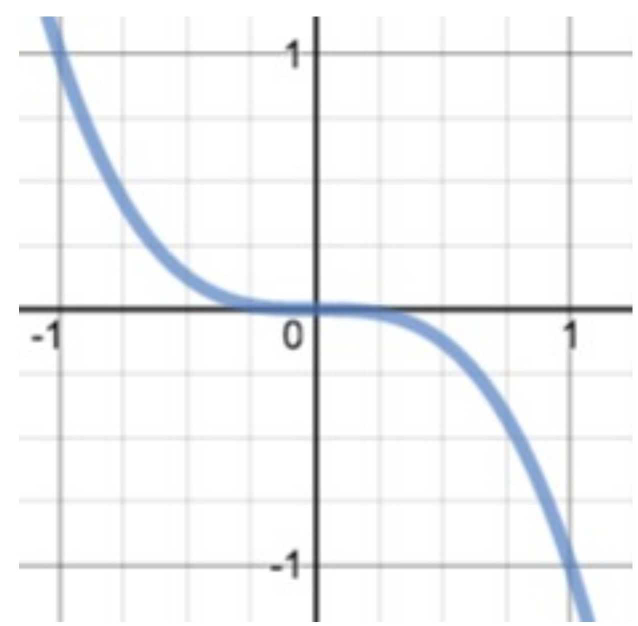

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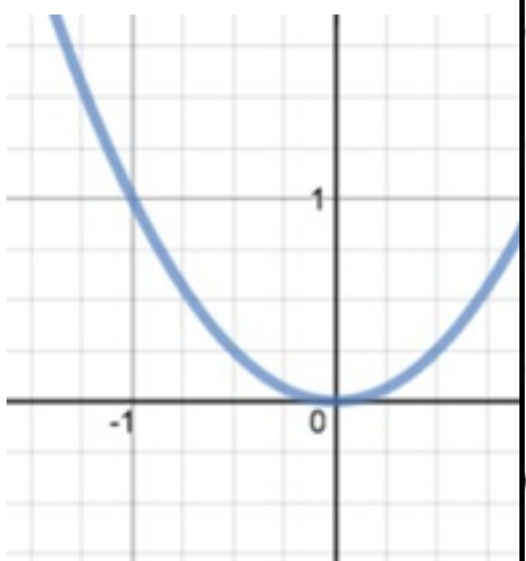
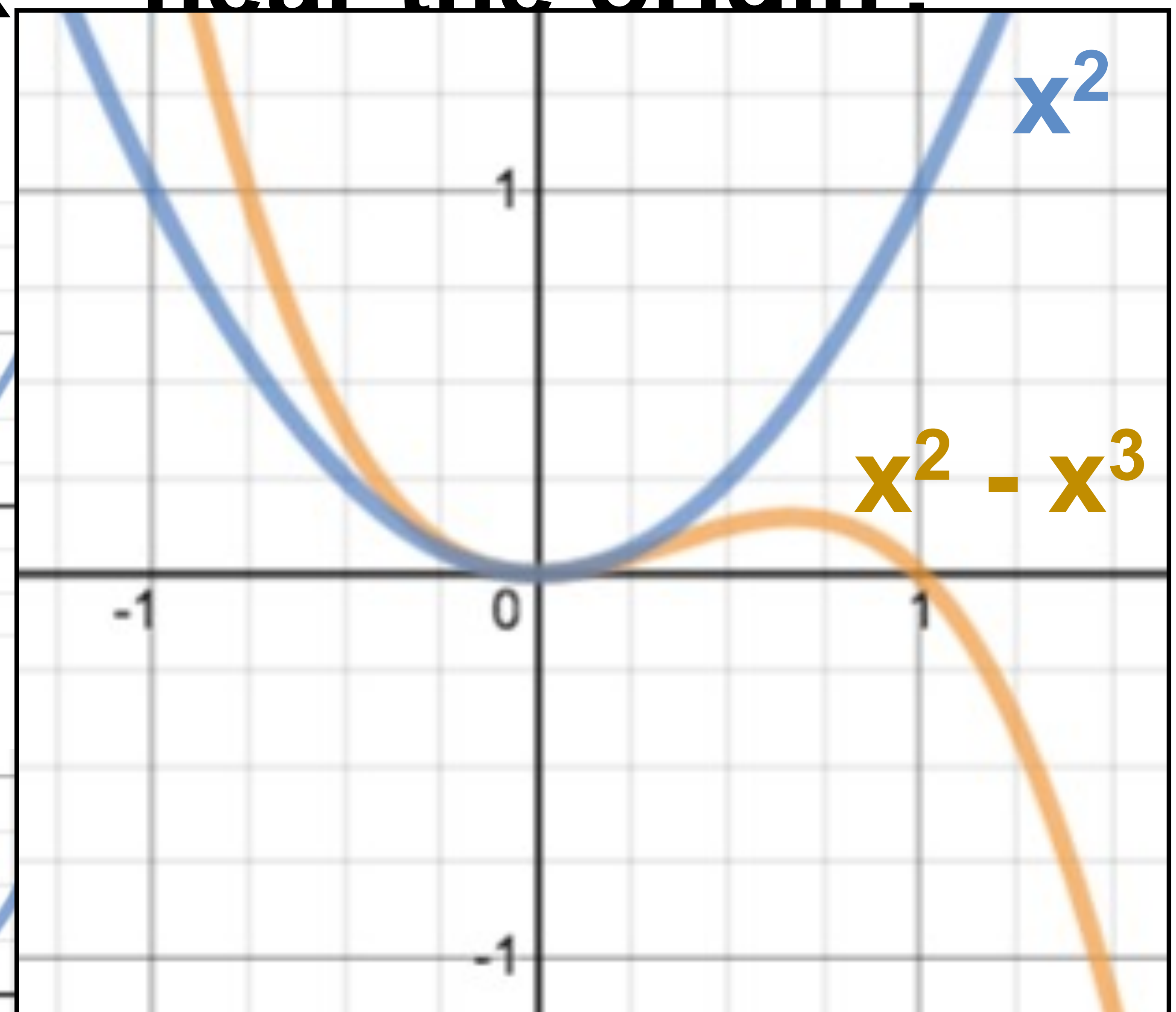
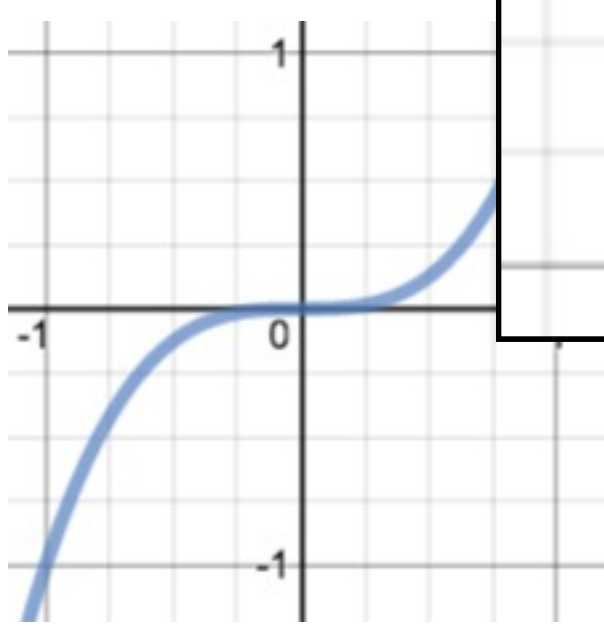
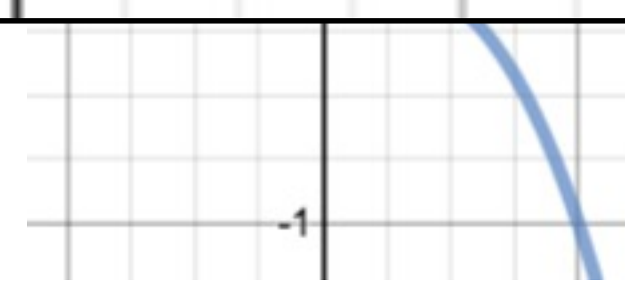




(C)





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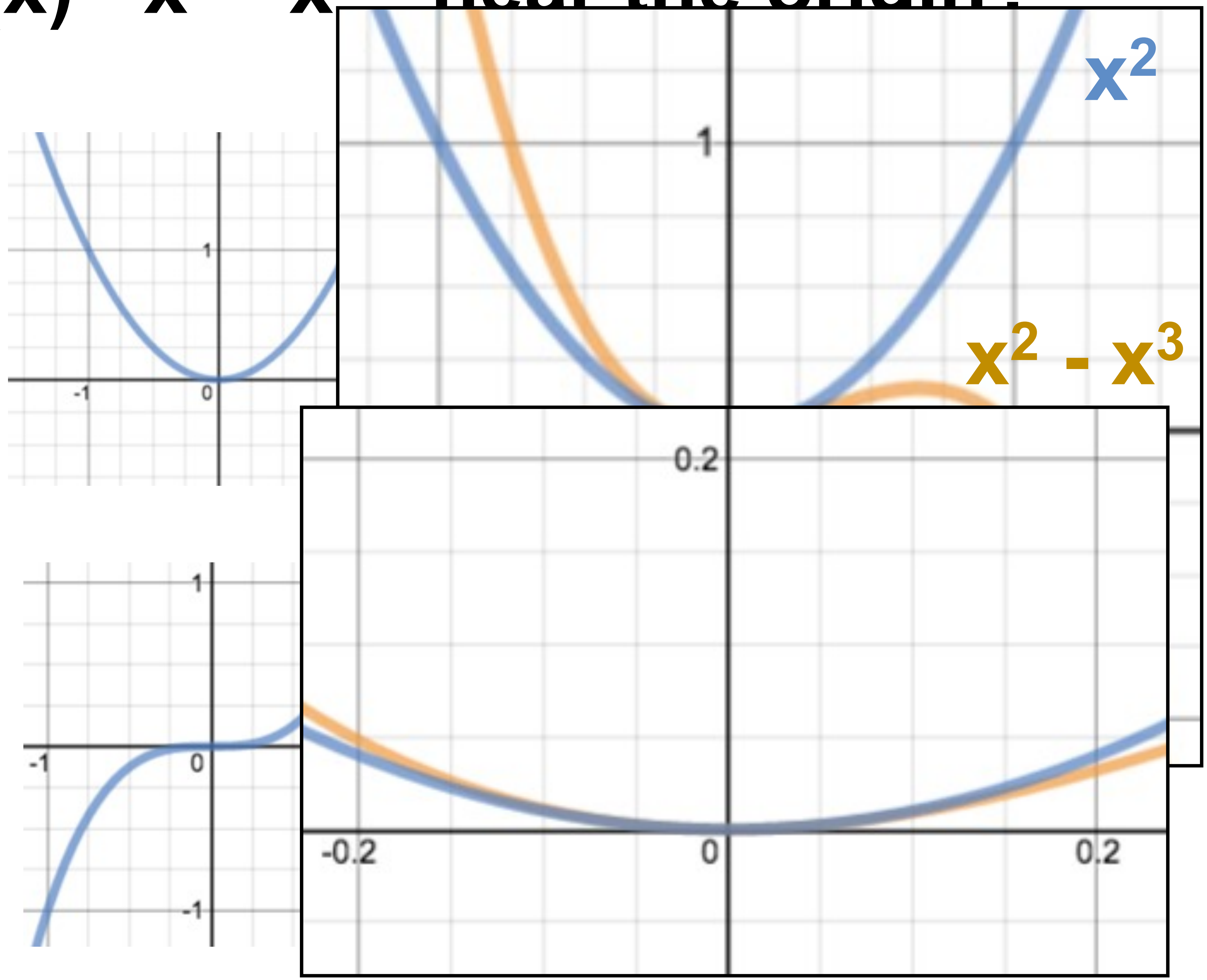

When $|x| >> 1$, then $x^2 - x^3$ can be approximated by...

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(C) None of the above.

(D) Don’t know - please explain.

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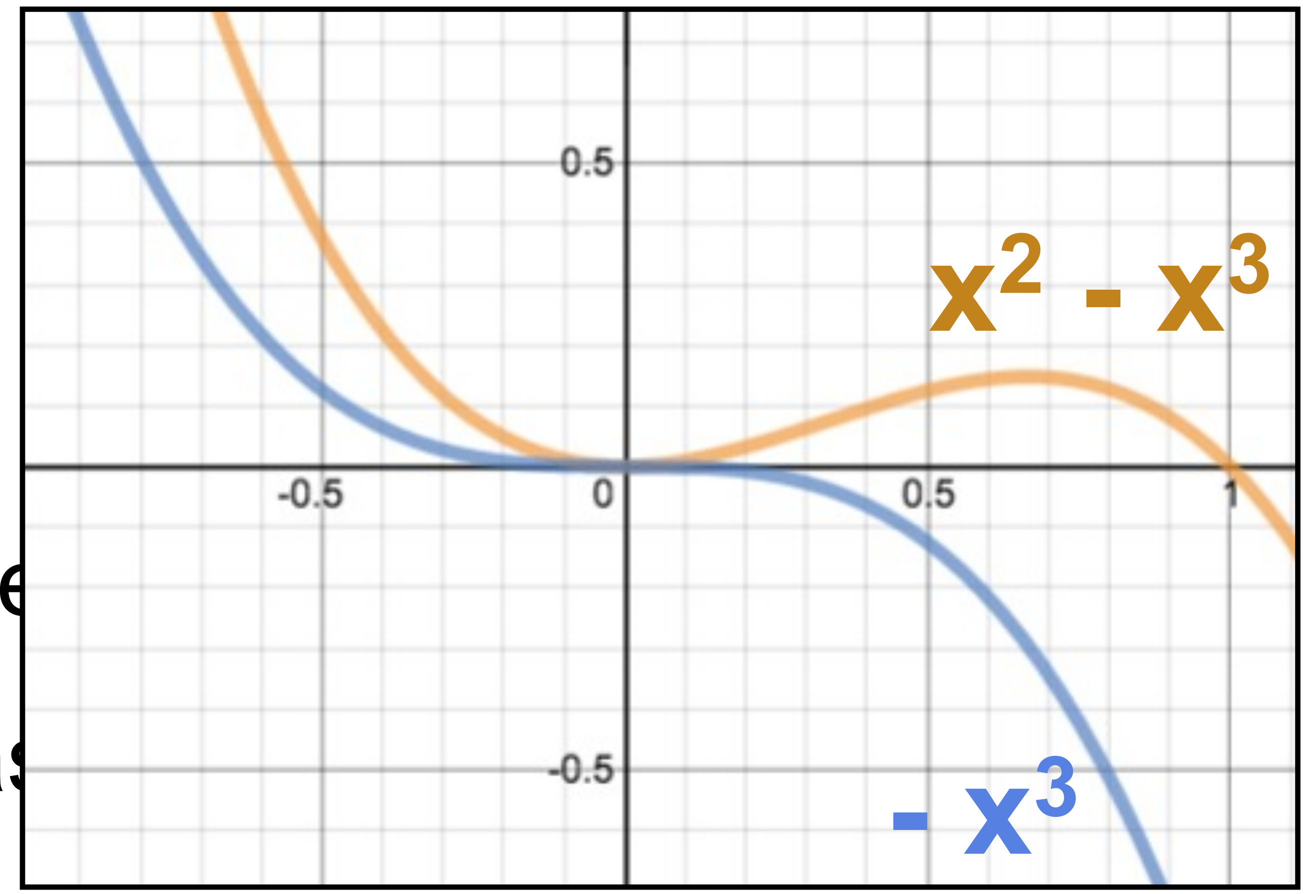

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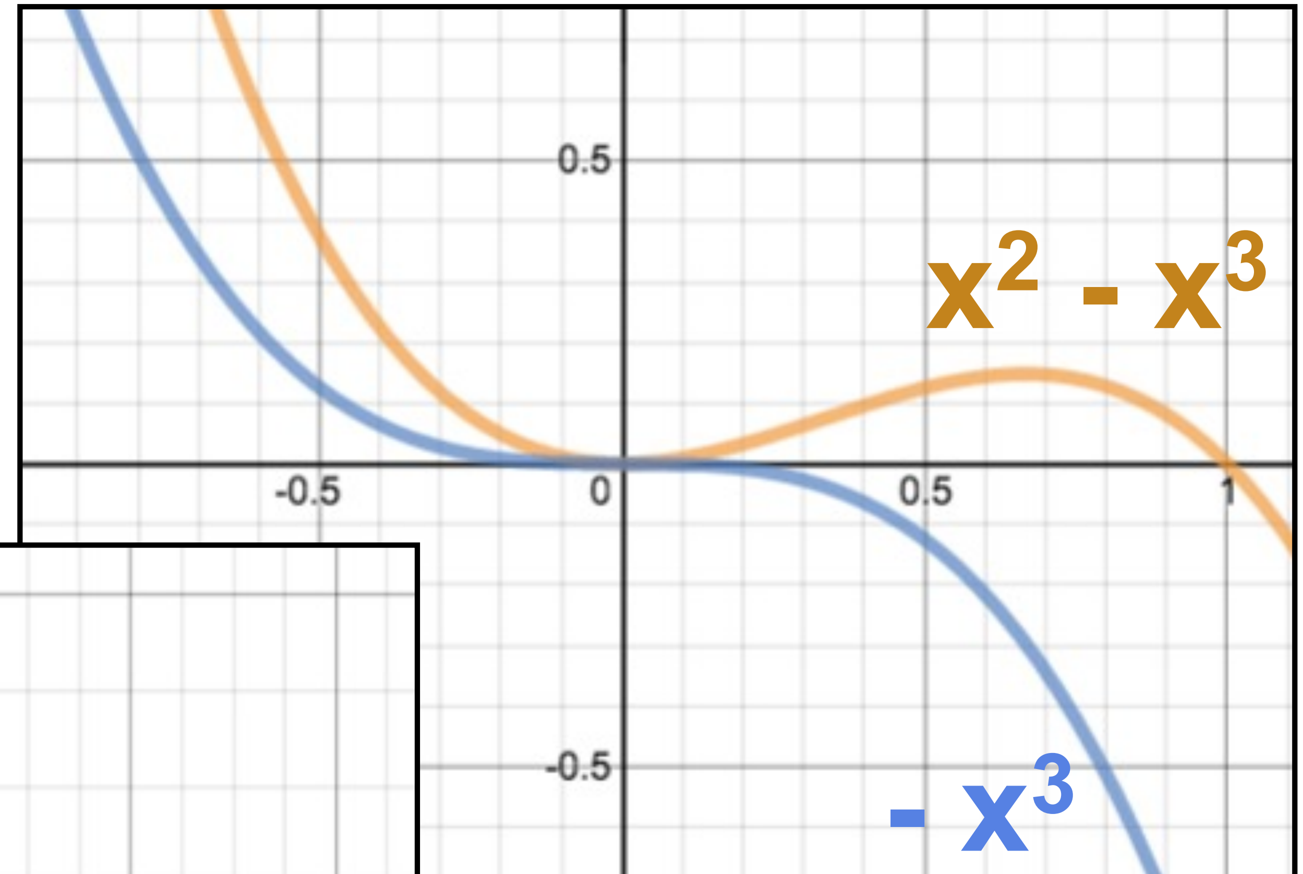

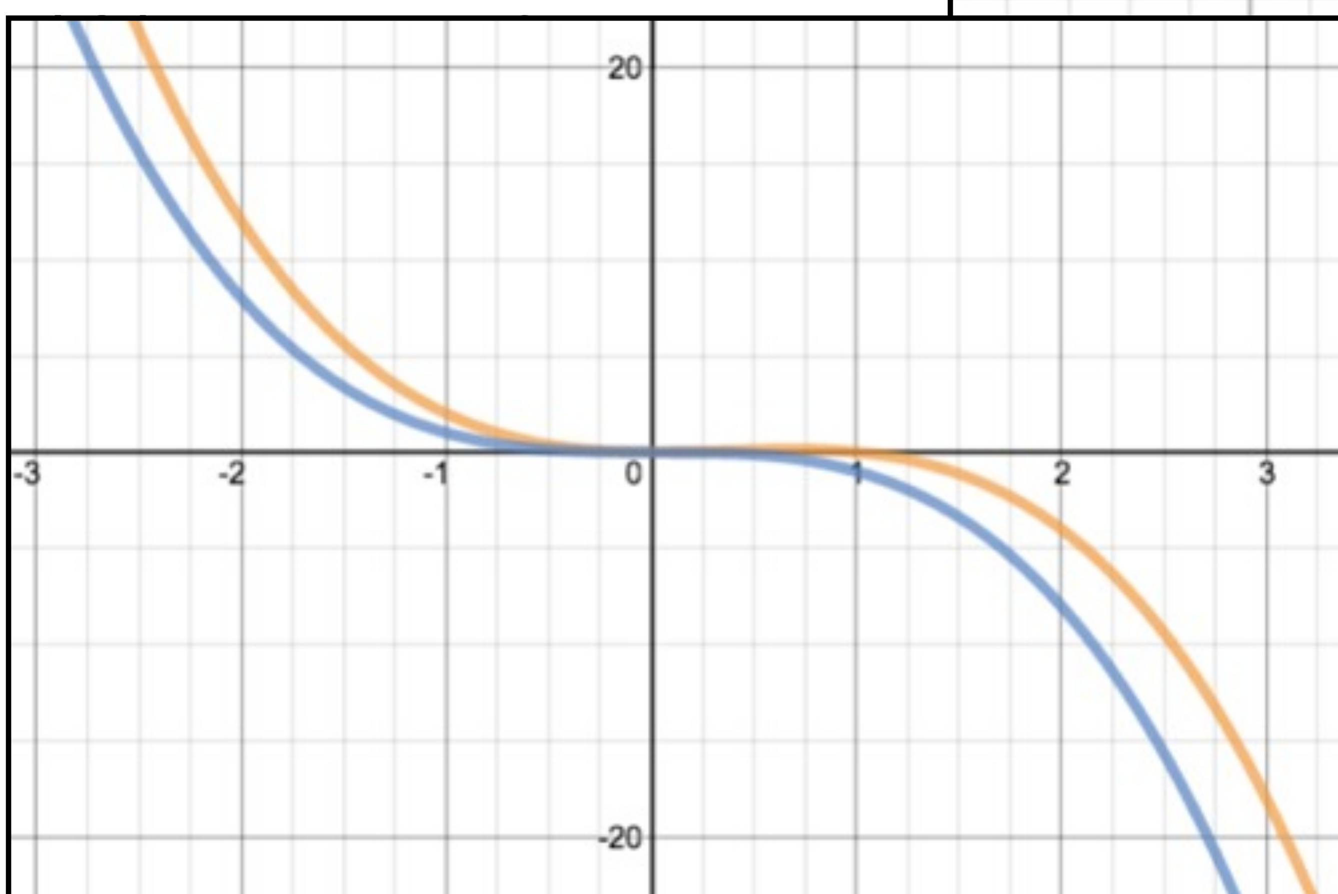

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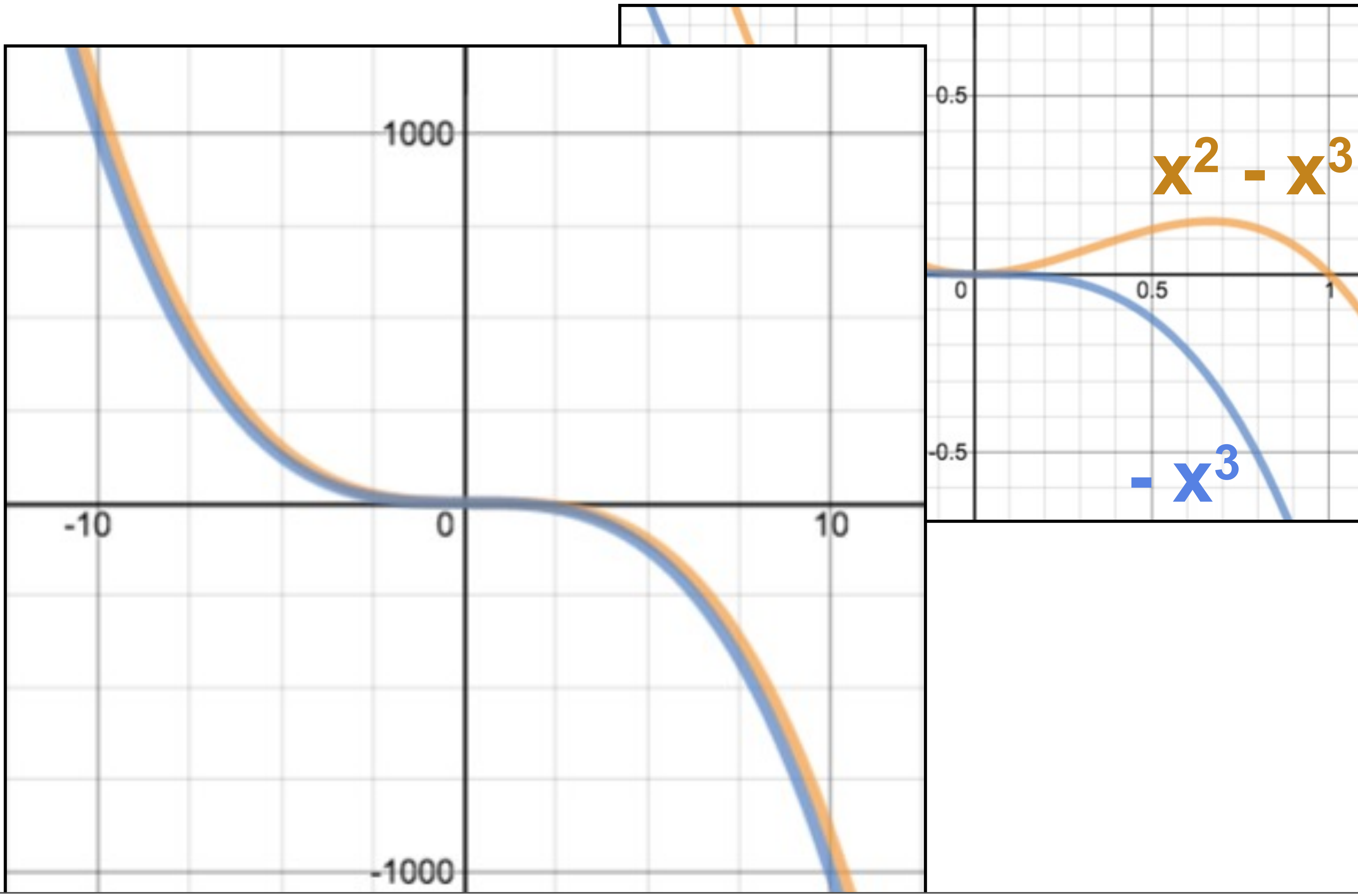

Coming up next lecture

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