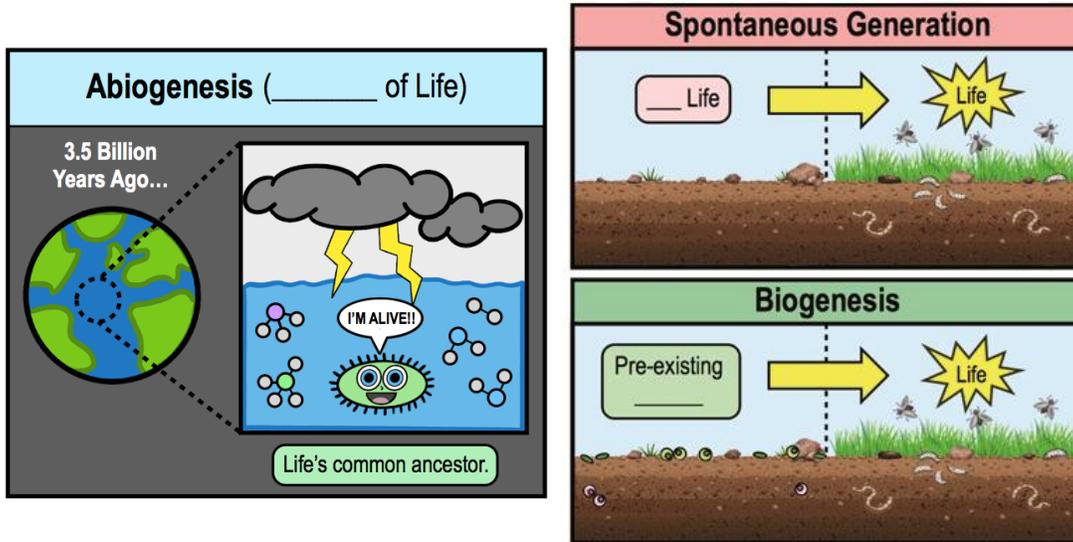


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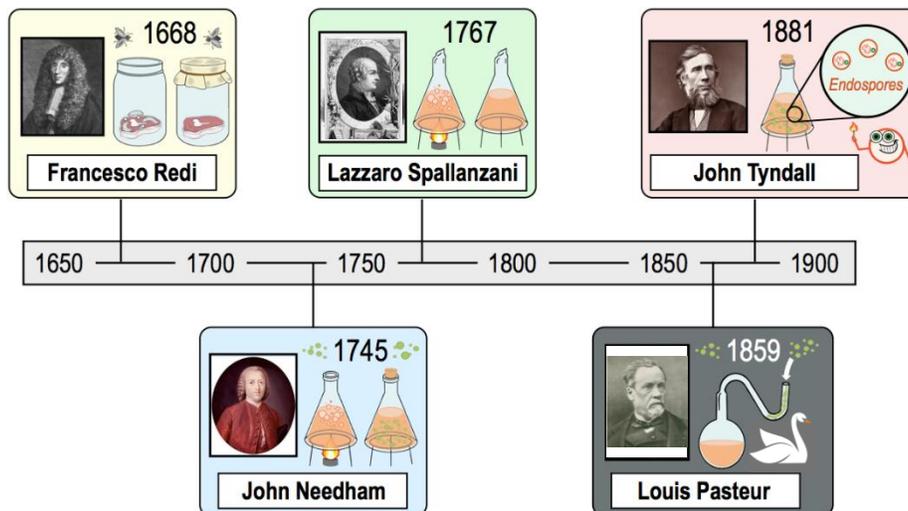
**CONCEPT: INTRODUCTION TO SPONTANEOUS GENERATION**

- Today it is well known that \_\_\_\_\_ life is only produced by \_\_\_\_\_-existing life, but that was not always the case.
- For *thousands* of years, many \_\_\_\_\_ believed *life generated from non-living material*.
  - **Spontaneous Generation:** *regular conversion of \_\_\_\_\_-living matter to complex living organisms (soil → worms).*
  - \_\_\_\_\_ **biogenesis:** *theory of a \_\_\_\_\_, likely onetime event of the origin of simple life from non-living matter.*
  - \_\_\_\_\_ **genesis:** *theory that living organisms arise only from \_\_\_\_\_-existing life.*



**Biogenesis vs. Spontaneous Generation**

- From 1668 to 1881, many experiments were conducted to either prove/disprove *biogenesis* or *spontaneous generation*.



**PRACTICE:** \_\_\_\_\_ is the theory that living organisms require pre-existing life in order to generate.

- a) Abiogenesis.
- b) Biogenesis.
- c) Evolution.
- d) Spontaneous Generation.

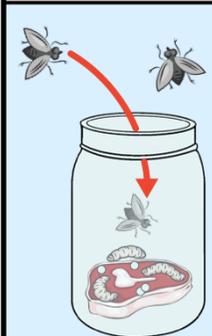
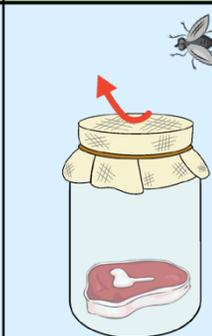
**CONCEPT: FRANCESCO REDI'S EXPERIMENTS**

- **Francesco** \_\_\_\_\_: Italian scientist that became the *first* to \_\_\_\_\_ the idea of *spontaneous generation*.
- Designed a simple experiment to prove that fly eggs & maggots do \_\_\_\_\_ *spontaneously generate* from decaying meat.
  - First piece of meat was left \_\_\_\_\_ to *allow* flies to enter & lay their eggs on the meat.
  - Second piece of meat was \_\_\_\_\_ with fine gauze to *prevent* flies from entering & laying their eggs.
- **Results:** fly eggs & maggots appeared on meat in uncovered jar but did \_\_\_\_\_ appear on meat in the covered jar.
- **Conclusion:** fly eggs & maggots (*life*) do \_\_\_\_\_ spontaneously generate from decaying meat (*non-living matter*).

Experiment Date:  
**1668**



Francesco Redi  
1626-1697

Open Jar	_____ Jar
	
<div style="border: 1px solid black; padding: 2px; background-color: #ffe6e6;">Fly eggs &amp; maggots _____.</div>	<div style="border: 1px solid black; padding: 2px; background-color: #e6ffe6;">Fly eggs &amp; maggots absent.</div>

Experiment Conclusions:

- ① Maggots develop from eggs laid on the meat by flies.
- ② Fly eggs & maggots do \_\_\_\_\_ spontaneously generate.

- Despite Redi's experiment, many scientists remained skeptical & were still determined to prove spontaneous generation.

**PRACTICE:** Which of the following statements about Francesco Redi's experiments is TRUE?

- a) He proved that bacteria were the cause of some types of diseases.
- b) He used chicken broth to disprove spontaneous generation.
- c) He showed that maggots could only form on raw meat if flies are able to lay their eggs on it.
- d) He showed that maggots spontaneously form on raw meat.
- e) All are true.
- f) None are true.

CONCEPT: NEEDHAM VS. SPALLANZANI

Needham's Results Incorrectly Supported Spontaneous Generation

- **John** \_\_\_\_\_: scientist & priest who tried to experimentally \_\_\_\_\_ *spontaneous generation*.
  - Had *poor* experimental setup & *incorrectly* believed that \_\_\_\_\_ *boiling a broth* would **sterilize** it.
  - **Sterilization**: process of killing \_\_\_\_\_ microbes in a sample.
- **Results**: after *briefly* boiling a flask of broth, allowing it to cool & sealing it with a cork, Needham saw *microbial growth*.
- **Conclusion**: Needham \_\_\_\_\_ concluded that his “sterile” flask of broth spontaneously generated microbes.

**EXAMPLE:** Poor Experimental Setup Led Needham to Incorrectly Support Spontaneous Generation of Microbes.

**Experiment Date:** 1745

Uhhh... Something isn't right here.

Look!! I did it!

**John Needham**  
1713-1781

**Spallanzani**

Broth boiled for a \_\_\_\_\_ amount of time.

Broth allowed to cool.

Broth developed microorganisms.

Flask sealed with a \_\_\_\_\_.

**Takeaways from Needham's Experiment**

- 1 **Incorrectly** believed all microbes died with a brief boiling.
- 2 **Incorrectly** believed a cork seal would prevent contamination.
- 3 **Incorrectly** concluded his experiments supported spontaneous generation.

- It was not until 1776 that the scientist, Lazzaro Spallanzani, performed a set of experiments to *contradict* these findings.

**PRACTICE:** Which of the following cannot be an explanation of the microorganisms present in Needham's flasks?

- a) The microorganisms could have entered his flask after it was boiled and before it was sealed properly.
- b) Microorganisms had developed spontaneously from the molecules in the broth when it was cooled.
- c) He did not boil his broth for a long enough time to completely kill all of the microorganisms.
- d) The cork that he used was porous and allowed microorganisms to enter the sealed flask.

**PRACTICE:** Which of the following individuals argued in favor of the theory of spontaneous generation?

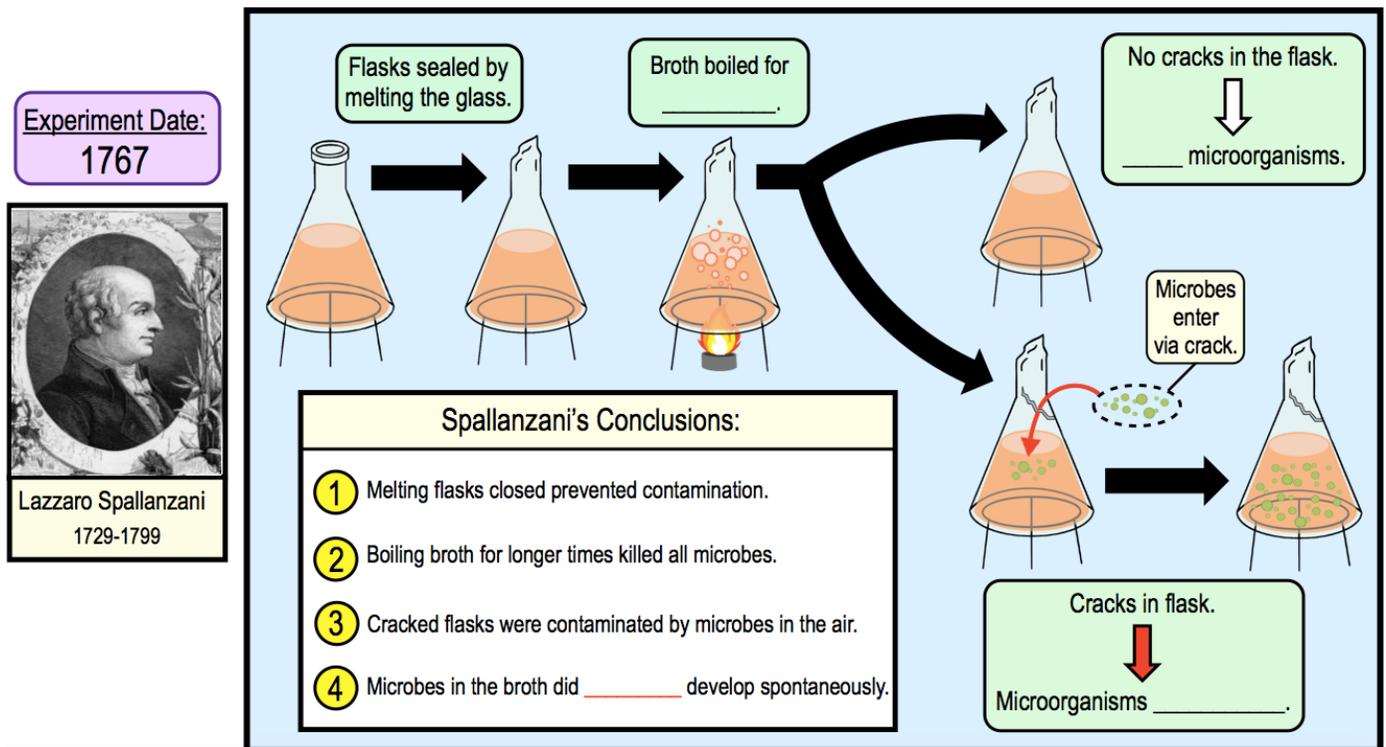
- a) Francesco Redi.
- b) Louis Pasteur.
- c) John Needham.
- d) Lazzaro Spallanzani.
- e) Isaac Newton.

**CONCEPT: NEEDHAM VS. SPALLANZANI**

**Spallanzani's Results Disproved Spontaneous Generation**

- **Lazzaro** \_\_\_\_\_: Italian physiologist who performed experiments that *contradicted* Needham's results.
  - Proposed that Needham's experiment was *flawed* & that organisms do \_\_\_\_\_ *spontaneously generate*.
- Spallanzani \_\_\_\_\_ flask by *melting it closed* & then boiled broth for a \_\_\_\_\_ period of time.
- **Results:** Spallanzani \_\_\_\_\_ saw microbial growth in sealed flasks; only saw growth in flasks that were *cracked*.
- **Conclusion:** microbes do \_\_\_\_\_ *spontaneously generate*; *cracked* flasks allowed microbes to enter from the air.

**EXAMPLE:** Spallanzani's Experiment Disproved Spontaneous Generation of Microbes.



- Opposers claimed Spallanzani's sealed flasks excluded a "vital source" that was needed for spontaneous generation.

**PRACTICE:** Spallanzani set out to disprove spontaneous generation by, however his findings were not accepted by all.

Why did some scientists disprove his findings?

- a) He did not boil the broth for long enough.
- b) He boiled the broth too long, killing the "vital source" that some believed was needed for spontaneous generation.
- c) He used the wrong type of flask and cork to seal his flask.
- d) He did not allow air in the flask which some believed was needed for spontaneous generation.
- e) A and C.
- f) B and D.

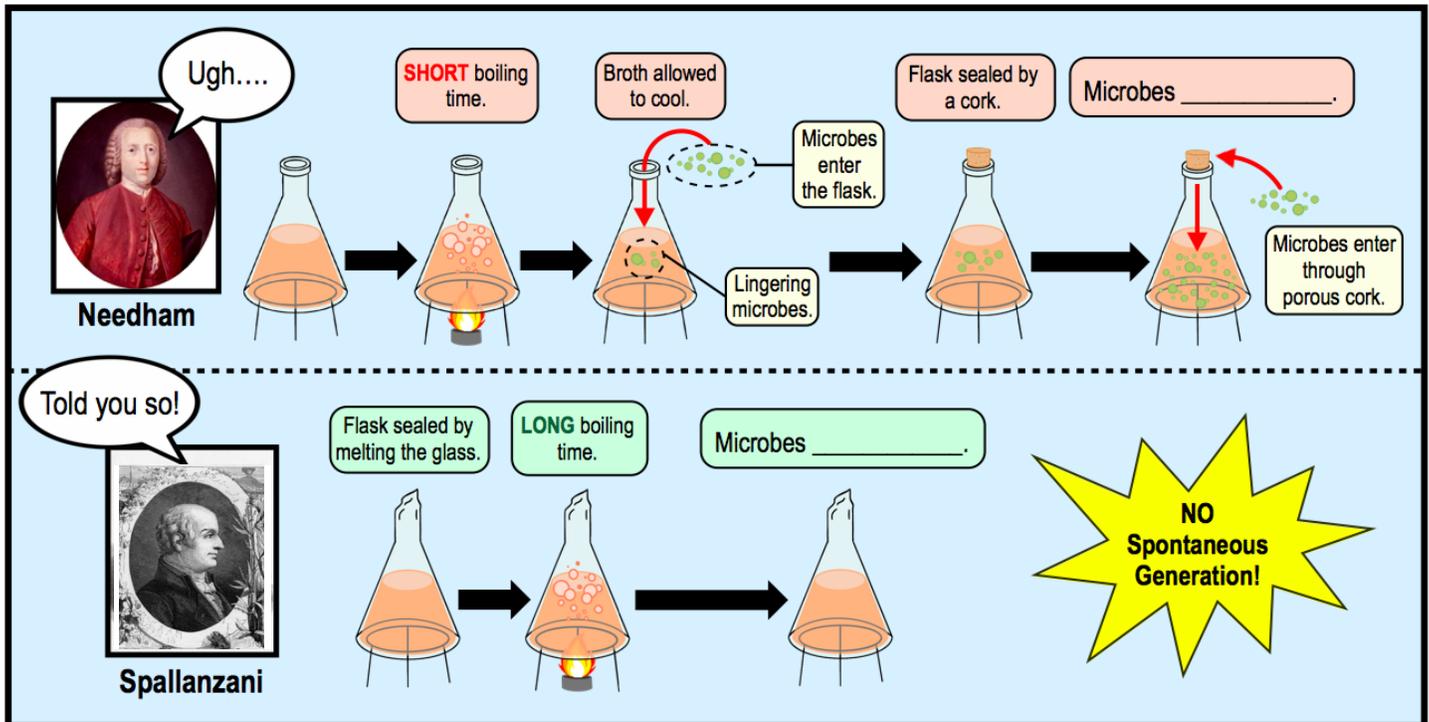
**CONCEPT: NEEDHAM VS. SPALLANZANI**

**Needham vs. Spallanzani Experimental Design**

● Spallanzani's experiments differed from Needham's in 2 *significant* ways:

- 1) Completely sealed flasks by \_\_\_\_\_ them before boiling (ensured no microbes entered *after* boiling).
- 2) Boiled the *broths* for a \_\_\_\_\_ period of time (ensured that ALL microbes were killed by heat).

**EXAMPLE:** Needham's vs. Spallanzani's Experiments.



- Some people still remained *skeptical* of biogenesis, even after Spallanzani's experiment.
- Almost 100 years later, Louis Pasteur confirmed Spallanzani's findings using a simple experiment with a custom flask.

**PRACTICE:** Needham performed an experiment by boiling chicken broth, placing it in a sterile flask, and then sealing the flask. After a few days, he observed microorganism growth in the flask. What was the major flaw of his experiment?

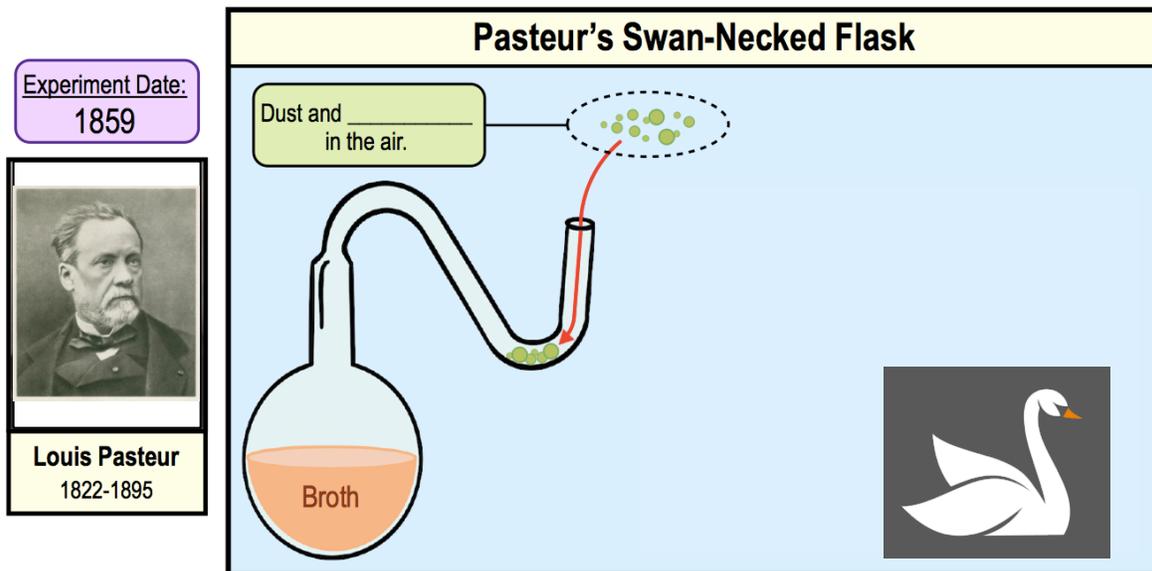
- a) Boiling the broth activated dormant microorganisms that were not present before boiling.
- b) Melting the flasks closed did not allow fresh air to interact with the broth, stopping microorganisms from developing.
- c) Needham boiled the broth too long, killing the "vital source" needed to develop microorganisms.
- d) He did not boil the broth long enough to kill all microorganisms and he did not seal the flask properly.

The flasks he used were cracked, and microorganisms from the air contaminated the broth.

**CH. 2 - DISPROVING SPONTANEOUS GENERATION**
**CONCEPT: PASTEUR'S EXPERIMENTS ON SPONTANEOUS GENERATION**

- **Louis** \_\_\_\_\_: French chemist who demonstrated that microbes are all around us, including in the air.
- Based on Spallanzani's results, Pasteur wanted to show that \_\_\_\_\_ was the source of microbial *contamination*.
  - Designed a simple set of experiments using a specialized type of \_\_\_\_\_.
- \_\_\_\_\_-**Neck Flasks**: specialized flasks designed by Pasteur to have a *long & curved* tube leading into the top of it.
  - Allowed air to enter, BUT dust & microbes in the air would get \_\_\_\_\_ in neck's bend.

**EXAMPLE:** Pasteur's Swan-Neck Flask Disproved Spontaneous Generation.



- Using his swan-neck flask, Pasteur conducted an experiment that \_\_\_\_\_ spontaneous generation.

**PRACTICE:** Louis Pasteur designed swan-necked flasks to:

- a) Keep maggots away from decaying meat.
- b) Pasteurize beer and wine.
- c) Trap microorganisms from the air in the neck of the flask.
- d) Allow dust to reach sterile infusions.

**PRACTICE:** Why did Pasteur design swan-necked flasks in his experiments on spontaneous generation?

- a) The neck excluded oxygen from entering the flask.
- b) The neck stopped microorganisms in the air from contaminating the contents of the flask.
- c) The neck excluded flies and maggots from entering the flask.
- d) The neck served as a handle when heating the flask.
- e) The neck prevented Pasteur from contaminating his sample by sneezing on it.

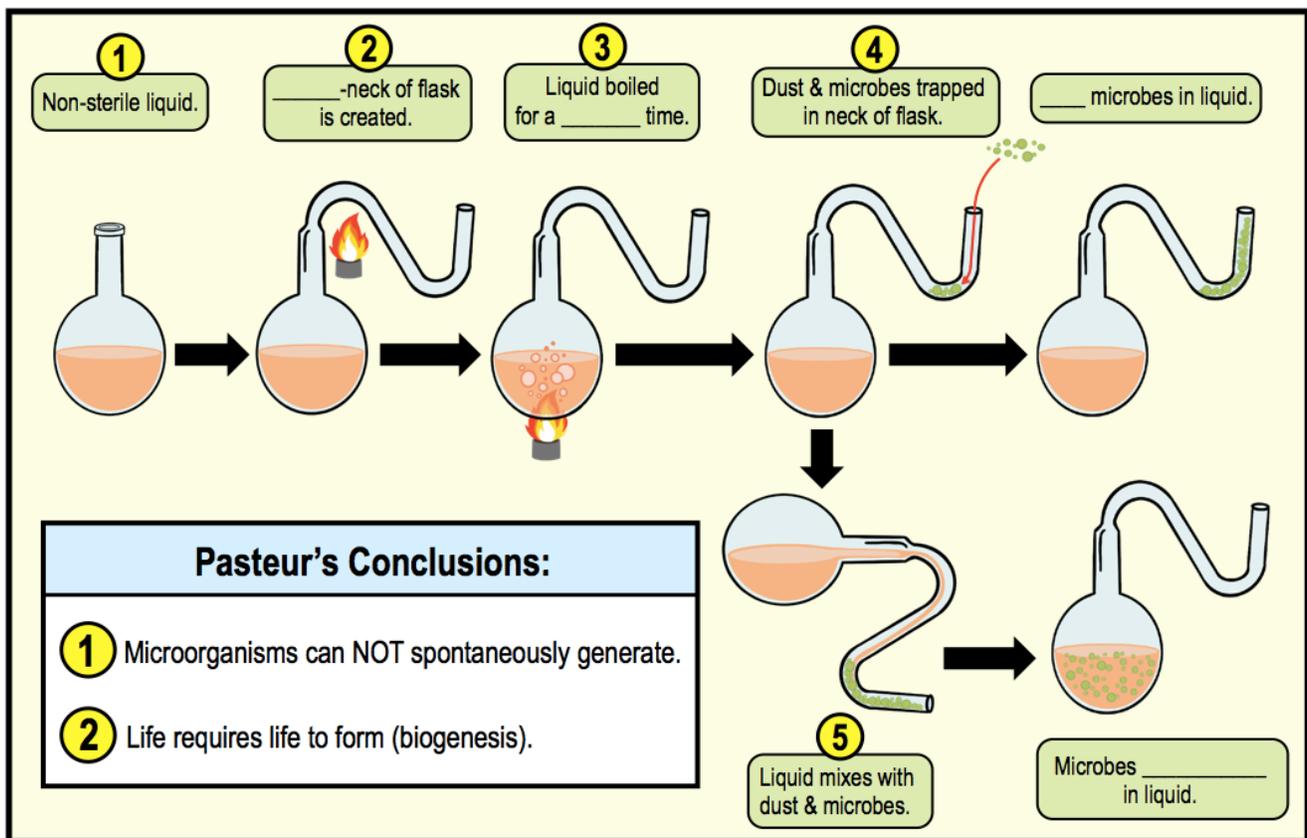
**CONCEPT: PASTEUR'S EXPERIMENTS ON SPONTANEOUS GENERATION**

**Pasteur's Swan-Neck Experiment**

● Pasteur's experiment consisted of the following 5 steps:

- 1) Flask is filled with a \_\_\_\_\_-sterile liquid broth.
- 2) \_\_\_\_\_-neck of the flask is formed with heat.
- 3) Broth is \_\_\_\_\_ by extensive heating.
- 4) As the flask cools, dust & microbes from the air get \_\_\_\_\_ in the bend of the Swan-neck.
  - Broth remained sterile \_\_\_\_\_ or until step 5.
- 5) \_\_\_\_\_ the flask mixes trapped microbes with the sterile broth & microbial growth is observed.

**EXAMPLE:** The steps of Pasteur's swan-neck experiment which ended the controversy of spontaneous generation.



**PRACTICE:** Which of the following is not a valid conclusion and/or outcome of Pasteur's experiment refuting the theory of spontaneous generation?

- a) That microorganisms are present everywhere, even in the air.
- b) The development of aseptic techniques when working with microbial cultures.
- c) Microorganisms can cause disease.

Living cells can only develop from pre-existing cells.

**CONCEPT: JOHN TYNDALL'S EXPERIMENT**

- One drawback from Pasteur's results were that NOT every scientist could \_\_\_\_\_ them.
  - Some scientists still discovered microbial growth in a swan-neck flask, even after "sterilizing" with \_\_\_\_\_.
- **John \_\_\_\_\_**: physicist that showed & explained why Pasteur's experiment could NOT always be replicated.
  - Found that some types of broth could \_\_\_\_\_ be *sterilized*, even after extremely long boiling times.
- Tyndall realized that, depending on the type of broth, they could contain different types of microbes:
  - 1) **Heat-Sensitive Microbes**: \_\_\_\_\_ when exposed to high enough heat.
  - 2) **Heat-Resistant Microbes**: can tolerate & \_\_\_\_\_ high levels of heat.

**EXAMPLE:** Tyndall showed why some scientists could not replicate Pasteur's results & further validated biogenesis.

Experiment Date:  
**1881**

**John Tyndall**  
1820-1893

**Experiment Conclusions:**

Microbes can exist in 2 forms:

- ① Heat - \_\_\_\_\_
- ② Heat - \_\_\_\_\_

*Sterilization techniques vary for different types of microbes*

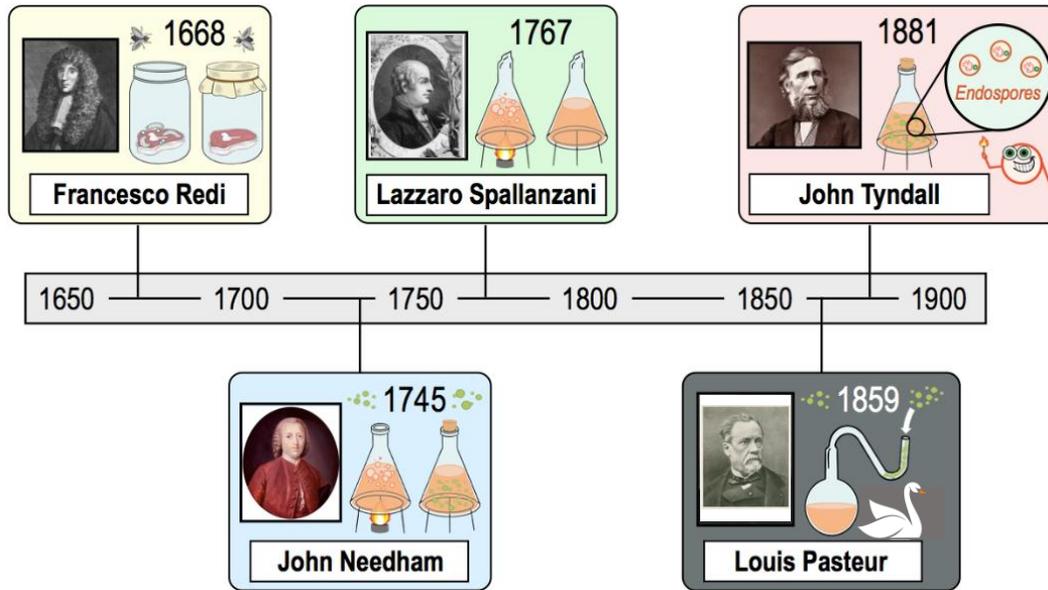
- In the same year, the scientist Ferdinand Cohen discovered \_\_\_\_\_: heat-resistant forms of *some* bacteria.
  - Scientists with *endospore* contaminants could \_\_\_\_\_ replicate Pasteur's results.

**PRACTICE:** Louis Pasteur and John Tyndall worked together to:

- a) Develop antiseptic surgery.
- b) Disprove that microorganisms could arise from non-living matter.
- c) Discover the cause of French wine spoilage.
- d) Develop a cholera vaccine.
- e) Develop methods for isolating bacteria in pure culture.

**CONCEPT: HISTORY OF SPONTANEOUS GENERATION SUMMARIZED**

● We can use the following timeline to review the scientists who studied spontaneous generation:



**PRACTICE:** Who was the first person to challenge the theory of spontaneous generation?

- a) Louis Pasteur.    b) Francesco Redi.    c) John Needham.    d) Lazzaro Spallanzani.    e) John Tyndall.

**PRACTICE:** Which of the following scientists argued in the favor of spontaneous generation?

- a) Lazzaro Spallanzani.    b) John Tyndall.    c) John Needham.    d) Louis Pasteur.    e) Francesco Redi.

**PRACTICE:** Spallanzani and Pasteur both disproved spontaneous generation in their experiments. What did Pasteur do differently that still allowed him to come to the same conclusion as Spallanzani?

- a) Air could enter the flasks, but microorganisms and dust particles could not enter.  
 b) No air could enter the flasks, but microorganisms could enter.  
 c) Neither air nor microorganisms could enter the flasks.  
 d) Both air and microorganisms could enter the flasks.

**PRACTICE:** Which of the following scientists showed that maggots develop from fly eggs that are laid on decaying meat rather than arising spontaneously.

- a) Lazzaro Spallanzani.    b) John Tyndall.    c) John Needham.    d) Louis Pasteur.    e) Francesco Redi.