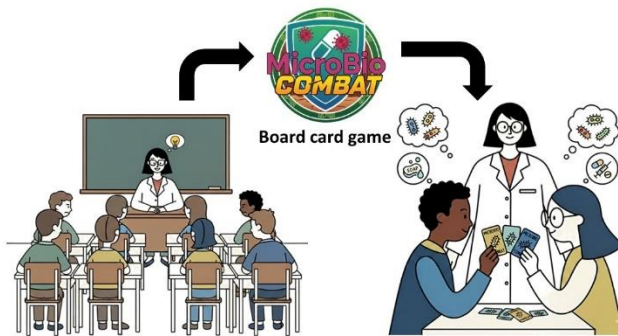


Short title (1-5 words): MicroBioCombat: Microbiology Educational Card Game

Short description: MicroBioCombat is a low-cost, card-based educational game for secondary schools. It gamifies microbiology by simulating infectious disease scenarios, enabling students to explore pathogen biology, transmission routes, and immune defenses. The tool enhances conceptual integration, strategic reasoning, and scientific engagement, particularly in resource-limited educational settings.

Picture for the thumbnail:



Any credits required to be included: Resource developed by Raul Vinicius Salata Souto, Edmara Rocha dos Santos Moreira, and Leandro Marcio Moreira (Federal University of Ouro Preto, Brazil).

Other putative important information

Target Audience: Secondary School Students (ages 14–16), though it can also be adapted for higher education settings.

Learning objectives:

- Identify pathogenic bacterial genera and transmission modes.
- Explain bacterial infection mechanisms and host immune responses.
- Integrate multidisciplinary concepts (microbiology, epidemiology, immunology).

Game components:

- 81 unique cards (Pathogens, Defense Strategies, Transmission/Aiding Mechanisms).
- "Vital Energy" scoring table.
- Rules manual.

Gameplay overview: MicroBioCombat is inspired by strategic card games like Magic: The Gathering™. Players use "Energy Points" (determined by dice) to activate cards. The game simulates biological conflicts: attacking with pathogens/transmission cards and countering with defense/prevention cards. The goal is to reduce the opponent's "Vital Energy" to zero.

Implementation guide:

- **Preparation:** Introduce bacterial diversity, morphology, and immune defenses via expository lecture.

- **Gameplay:** Organize students into pairs/groups. Distribute decks and scoring tables.
- **Synthesis:** Debrief gameplay, develop concept maps connecting pathogens, vectors, and defense strategies.

Printable materials: Supplementary Files 1, 2, and 3 of the article "*Game-Based Learning in Microbiology Education: Design and Classroom Use of MicroBioCombat*," published in the pedagogy section of the journal Access Microbiology.

Game-Based Learning in Microbiology Education: Design and Classroom Use of *MicroBioCombat*

Raul Vinicius Salata Souto¹, Edmara Rocha dos Santos Moreira¹
and Leandro Marcio Moreira^{1,2#}

Supplementary File 3: Game rules for printing.



TEACHER'S GUIDE

Ouro Preto, Minas Gerais, Brazil

TEACHER'S GUIDE

MicroBioCombat

1. About the Game

MicroBioCombat is an educational card game inspired by strategy-based games such as *Magic: The Gathering*™. It was designed to teach microbiology in an engaging and interactive way, especially at the high school level.

The game simulates “biological battles” involving:

- Pathogenic bacteria
- Transmission mechanisms
- Defense and prevention strategies

Through strategic gameplay, students apply microbiology concepts in a playful but structured environment. The game works as a **low-cost virtual laboratory**, allowing teachers to simulate complex biological processes even in schools without laboratory facilities.

2. Learning Objectives

2.1. Cognitive Goals

Students will be able to:

- Identify pathogenic bacteria and their characteristics
- Understand how infections are transmitted
- Connect pathogens to affected organs and symptoms
- Recognize host defense mechanisms
- Understand prevention strategies such as vaccines and hygiene

2.2. Skills Development

Students will:

- Apply scientific concepts to problem-solving situations
- Develop strategic reasoning
- Integrate multiple biological concepts in decision-making

2.3. Social and Emotional Skills

The game promotes:

- Teamwork
- Scientific argumentation
- Leadership and respectful discussion
- Reduced anxiety toward complex scientific topics

3. Guidance for Teachers

3.1. Before Playing

It is recommended to prepare students with:

- A lesson covering:
 - Domain Bacteria / Archaea
 - Bacterial morphology and physiology
 - Commensal vs pathogenic relationships
 - Antibiotic resistance
 - Basic immune system concepts
- A short diagnostic activity to assess prior knowledge

3.2. During the Game

The teacher acts as:

- A scientific mediator
- A facilitator of discussion
- A concept clarifier
- An observer of student reasoning

Encourage students to:

- Justify their moves biologically
- Use correct scientific vocabulary
- Explain why an attack or defense works

This step is essential for transforming the game into meaningful learning.

3.3. After the Game

Recommended activities:

- A post-game diagnostic activity
- Group discussion about strategies used
- Creation of concept maps connecting:
 - Pathogen
 - Transmission route
 - Target organ
 - Defense strategy

4. Game Components

MicroBioCombat includes:

- **81 Cards divided into three categories:**
- pathogenic bacteria (yellow = 26 cards),
- defense strategies (blue = 33 cards)
- mechanisms of conveyance and aiding of pathogens (purple = 22 cards)

4.1. Pathogenic Bacteria Cards (26 cards)

Each card includes:

- Scientific name
- Associated disease
- Biological characteristics
- Energy cost for activation
- Damage potential

4.4. Transmission / Conveyance Cards (22 cards)

Examples:

- Bloodstream
- Deep wound
- Contaminated food
- Anaerobic environment

These cards represent how bacteria reach the host.

4.3. Defense / Protection Cards (33 cards)

Examples:

- Vaccines (e.g., DPT)
- Antibiotics
- Immune cells (neutrophils, macrophages)
- Hygiene measures

- Environmental changes
- Healing ointments

Additional Materials

- 1 die.
- Pen or pencil.
- Vital Energy Table (score sheet) - Available as a separate downloadable file.

5. Game Setup

- Each player (or pair) starts with **20 life points**.
- Each player chooses **7 cards** from any category.
- Remaining cards stay in organized piles.
- The Vital Energy Table must be available to record life points.

The game can be played:

- Individually
- In pairs
- On a table or defined floor space

6. How to Play – Step by Step

6.1. Start of Each Round

1. The player rolls the die.
2. The number rolled equals the available **energy points**.
3. Unused energy points can be saved for future rounds.

6.2. Attack Phase

To attack:

- The player must activate a pathogenic bacteria card.
- In many cases, they must also activate a transmission card.
- The total energy cost must be equal to or lower than available energy.

If successful:

- The opponent loses life points equal to the attack cost.

6.3. Defense Phase

The opponent may:

- Roll the die
- Activate defense cards
- Block the attack if energy is sufficient and the defense is biologically appropriate

If the defense is scientifically coherent and energetically valid:

- The attack is neutralized.

6.4. Card Exchange

At the end of each full round:

- Players may exchange one card
- The returned card goes to the bottom of its original pile

6.5. Winning the Game

The winner is the player (or pair) who reduces the opponent's life points to **zero**.

7. Vital Energy Table (Scoring System)

Important:

- Record all damage immediately
- Update life points after each attack
- Track stored energy if accumulated

The table helps students:

- Visualize consequences of strategies
- Understand energy cost vs biological impact
- Reflect on decision-making

8. Example Scenarios

✓ Successful Attack

Staphylococcus aureus + Bloodstream

If the player has enough energy:

- The bacterium reaches systemic circulation
- The opponent loses life points
- Unless a valid defense is activated

✓ Successful Defense

Clostridium tetani + Deep Wound

Possible defenses:

- Aerobic environment (oxygen exposure)
- Healing ointment
- DPT vaccine

Students must explain:

- Why tetanus bacteria require anaerobic conditions
- How oxygen or vaccination prevents disease

This discussion is where the strongest learning happens.

9. Educational Impact

MicroBioCombat:

- Functions as a “virtual microbiology lab”
- Encourages critical thinking
- Promotes scientific dialogue
- Works well in low-resource schools
- Increases engagement and motivation

The game transforms abstract microbiology concepts into dynamic, interactive learning experiences.

10. Target Audience

- High school biology classes
- Upper middle school science
- Introductory microbiology courses

Game-Based Learning in Microbiology Education: Design and Classroom Use of *MicroBioCombat*

By

Raul Vinicius Salata Souto¹, Edmara Rocha dos Santos Moreira¹ and Leandro Marcio Moreira^{1,2#}

SUPPLEMENTARY MATERIAL

Supplementary Table 1. Overview of *MicroBioCombat* pathogens and vectors

N°	Card / Pathogen	Card Type	Cell Struct / Lifestyle	Pathology Diseases /	Game Effect / Function	Energy	Damage points
1	<i>Bacillus anthracis</i>	Pathogen	G+ A F	Anthrax	Infects via inhalation or spores; potent attack card	2	4
2	<i>Bordetella pertussis</i>	Pathogen	G- A	Whooping cough	Spread via droplets; damages opponent when used with "Spittle"	3	3
3	<i>Brucella sp.</i>	Pathogen	G- A F	Brucellosis	Spread via contaminated meat or vectors	2	2
4	<i>Clostridium botulinum</i>	Pathogen	G+ An P	Botulism	Entry via contaminated food; potent toxin card	2	5
5	<i>Clostridium perfringens</i>	Pathogen	G+ An P	Gas gangrene	Entry via wounds; damages opponent if combined with "Deep Wounds"	2	2
6	<i>Clostridium tetani</i>	Pathogen	G+ An P	Tetanus	Requires anaerobic wounds; damages over rounds	3	4
7	<i>Corynebacterium diphtheriae</i>	Pathogen	G+ A F	Diphtheria	Attack enhanced by "Lisogenic phage"; associated with throat infection	1	2
8	<i>Escherichia coli</i>	Pathogen	G- A F	Gastroenteritis	Can become pathogenic via "Biological risk" card	2	3
9	<i>Helicobacter pylori</i>	Pathogen	G- M	Peptic disease	Colonizes stomach; damage increased by "Stress"	1	3
10	<i>Leptospira interrogans</i>	Pathogen	G- A	Leptospirosis	Spread via rats and vectors	2	4
11	<i>Listeria monocytogenes</i>	Pathogen	G+ A F	Listeriosis	Enhanced by "Pregnancy" card; food-borne	3	4
12	<i>Mycobacterium tuberculosis</i>	Pathogen	*G+ A	Tuberculosis	Targets lungs; defended by neutrophils/macrophages	3	2
13	<i>Mycobacterium leprae</i>	Pathogen	*G+ A	Hansen's disease	Entry via open wounds; chronic infection card	3	3
14	<i>Neisseria gonorrhoeae</i>	Pathogen	G- A	Gonorrhea	Sexual transmission; attack card	1	2
15	<i>Neisseria meningitidis</i>	Pathogen	G- A	Meningitis	Spread via droplets; enhanced by "Spittle"	4	4
16	<i>Rickettsia prowazekii</i>	Pathogen	G- A	Epidemic typhus	Vector-borne; transmitted by lice	1	2
17	<i>Rickettsia rickettsii</i>	Pathogen	G- A	Rocky Mountain spotted fever	Vector-borne; transmitted by ticks	3	4
18	<i>Rickettsia typhi</i>	Pathogen	G- A	Endemic typhus	Transmitted by <i>Pediculus humanus</i>	1	2
19	<i>Salmonella sp.</i>	Pathogen	G- A F	Salmonellosis	Food-borne; entry enhanced by "Contaminated meat" or "Unpasteurized milk"	2	3
20	<i>Staphylococcus aureus</i>	Pathogen	G+ A F	Generalized infections	Entry via wounds; attack card	3	3
21	<i>Staphylococcus saprophyticus</i>	Pathogen	G+ A F	Cystitis	Sexual transmission; damage card	1	2
22	<i>Streptococcus pneumoniae</i>	Pathogen	G+ A	Bacterial pneumonia	Respiratory pathogen; combined with droplets	3	3
23	<i>Streptococcus pyogenes</i>	Pathogen	G+ A	Erysipelas	Entry via wounds; attack enhanced by throat infection	2	2
24	<i>Treponema pallidum</i>	Pathogen	G- M	Syphilis	Sexual transmission; attack card	3	2
25	<i>Vibrio cholerae</i>	Pathogen	G- A F	Cholera	Food/water transmission; strong damage card	1	3
26	<i>Yersinia pestis</i>	Pathogen	G- A N F	Bubonic plague	Vector-borne; enhanced via rat and flea cards	2	4

Cell Structure (Gram Staining): G+ (Gram-positive) - Indicates bacteria with a thick peptidoglycan cell wall; G- (Gram-negative) - Indicates bacteria with a thinner cell wall and an additional outer membrane. Lifestyle (Oxygen Metabolism): A (Aerobe) - Microorganisms that require oxygen to grow; An (Anaerobe) - Microorganisms that grow in the absence of oxygen; F (Facultative) - Also known as Facultative Anaerobes or microorganisms that can grow in both the presence and absence of oxygen. M (Microaerophilic) - Used to indicate specific atmospheric requirements or neutral growth conditions. P (Spore-former / Pleomorphic) - Refers to the ability to form spores for environmental survival. * Poorly visualized by Gram staining.

Supplementary Table 2. Defense and protection cards in *MicroBioCombat*

N°	Card Name	Card Type	Target	Effect / Function	Energy
1	Anaerobic environment	Environmental	Aerobic bacteria in attack	Kills all aerobic bacteria; prevails over defense cards	2
2	Aerobic environment	Environmental	Anaerobic bacteria in attack	Kills all anaerobic bacteria; prevails over defense cards	2
3	Penicillin	Antibiotic	<i>Treponema pallidum</i> , <i>Streptococcus pyogenes</i>	Destroys bacterial colonies of target pathogens	2
4	Phenol (carbolic acid)	Disinfectant	<i>Mycobacterium leprae</i> , <i>Mycobacterium tuberculosis</i>	Used with “1%” card to neutralize attacking bacteria	2
5	Biphenols (hexachlorophene)	Disinfectant	Gram-positive (<i>Streptococcus</i> , <i>Staphylococcus</i>)	Kills targeted bacteria on attack	1
6	Triclosan	Disinfectant	Gram-positive bacteria	Prevents attack for 2 rounds	2
7	Halogens (iodine)	Disinfectant	Open wound / Deep wound pathogens	Prevents pathogen entry for 1 round	2
8	Healing ointment	Treatment	—	Promotes recovery; assists immune defense	1
9	Platelets	Immune	—	Supports defense against attacking bacteria	1
10	Chlorine	Chemical defense	Water-borne bacteria	Protects individual for 2 rounds when combined with “Water” card	3
11	Alcohol 70%	Disinfectant	All bacteria	Protects individual for 1 round	2
12	Sodium nitrite	Food safety	Bacteria in “Contaminated meat”	Neutralizes attack; bacteria return to deck	2
13	Research and treatment	Medical	Attacking bacteria	Paralyzes attack for 2 rounds	1
14	Quaternary ammonium compounds	Disinfectant	Throat infection bacteria (except <i>Pseudomonas</i>)	Neutralizes attacks for 2 rounds; less effective in organic matter	2
15	Slow freezing	Physical defense	Attacking bacteria	Kills bacteria after 3 rounds via crystal formation	1
16	Fast freezing	Physical defense	Attacking bacteria	Paralyzes attack for 2 rounds; does not kill	1
17	Autoclave	Sterilization	All attacking bacteria	Kills all bacteria; requires “15 min” card	2
18	Pasteurization	Sterilization	All attacking bacteria	Kills bacteria from attacking opponent	5
19	Vitamin C	Immune booster	Macrophages / Neutrophils	Increases destructive power against 2 bacteria	2
20	Neutrophil	Immune	1 bacterium in attack	Kills bacteria; enhanced with Vitamin C / T4 lymphocytes	2
21	Macrophage	Immune	1 bacterium in attack	Kills bacteria; enhanced with Vitamin C / T4 lymphocytes	4
22	Aniquilating Serpent	Vector control	Rats transmitting plague	Removes rat cards from play; returns to deck	2
23	Poison against lice and ticks	Vector control	Lice / ticks	Eliminates vector cards; returns them to deck	3
24	Care in sexual relations	Behavioral	Sexually transmitted pathogens	Protects for 2 rounds	1
25	Decomposer bacteria	Biological	Food-borne bacteria	Removes multiplying bacteria from table	2
26	Health surveillance	Public health	Food-borne bacteria	Eliminates pathogens causing foodborne illness	0
27	Physical exercises	Immune booster	1 bacterium	Increases immune cell attack power	2
28	Keep calm	Behavioral	Stress card	Neutralizes “Stress” effect	1
29	<i>Bedellovibrio</i>	Bacteriophage / biological	1 Gram-negative bacterium	Kills targeted bacterium	1
30	Medical prescription	Antibiotic support	—	Enhances action of antibiotics cards	2
31	DPT vaccine	Vaccine	Diphtheria, Pertussis, Tetanus bacteria	Provides immunity to targeted pathogens	0
32	Water	Environmental	Chlorine card	Activates chlorine effectiveness against bacteria	1
33	Surfactant	Disinfectant	Surface pathogens / biofilms	Reduces pathogen adhesion; blocks attack for 1 round	4

Supplementary Table 3. Additional mechanisms and protection conditions

N°	Mechanism / Condition	Card Type	Target	Game Effect / Function	Energy
1	Bacterial transformation	Microbial process	Attacking bacteria	Increases genetic variability; evades antibiotic action	2
2	Bad eating habits	Host factor	Host immune cells	Reduces macrophage and neutrophil efficiency	1
3	Biological risk	Fostering	Commensal bacteria	Converts commensals into pathogens	2
4	Blood flow	Host factor / Fostering	Parasites / vectors	Allows direct entry of blood-borne pathogens	0
5	Conjugation	Microbial process	Attacking bacteria	Enhances variability; avoids antibiotics (except autoclave/pasteurization/surfactant)	2
6	Contaminated meat	Food-borne	Food-borne pathogens	Carries multiple pathogens; enables transmission	1
7	Deep wounds	Vector / Entry	Severe bacterial pathogens	Enables high-damage infections	2
8	Fibrin	Pathogen enhancer	All bacteria	Increases pathogen damage	2
9	Inhalation of spores	Vector	<i>Bacillus anthracis</i>	Enables infection via respiratory route	0
10	Kidney dysfunction	Host factor	<i>Streptococcus</i>	Induces nephritis if combined	0
11	Lysogenic phage	Fostering	<i>Corynebacterium</i>	Potentiates bacterial attack	2
12	Open wounds	Vector / Entry	Various bacteria	Enables pathogen entry	2
13	<i>Pediculus humanus</i>	Vector	<i>Rickettsia typhi</i>	Facilitates endemic typhus transmission	0
14	Pregnancy	Host factor / Fostering	<i>Listeria monocytogenes</i> , <i>Neisseria meningitidis</i>	Increases damage when associated	1
15	Rheumatic fever / Valve stenosis	Host factor	<i>Streptococcus</i>	Causes damage points depending on combination	0
16	Spittle	Vector / Fostering	Respiratory pathogens	Enhances pathogen spread	1
17	Spore intake	Vector	<i>Bacillus anthracis</i> , <i>Salmonella</i> spp.	Reintroduces bacteria; simulates rapid proliferation	1
18	Star tick bite	Vector	<i>Rickettsia rickettsii</i>	Facilitates Rocky Mountain spotted fever transmission	0
19	Stress	Fostering	Pathogens	Increases damage caused by pathogens	1
20	Throat infection	Host factor	<i>Streptococcus</i>	Boosts attack if combined with relevant cards	1
21	Unpasteurized milk	Food-borne	Food-borne bacteria	Reintroduces bacteria up to 3 times; simulates rapid proliferation	2
22	<i>Xenopsylla cheopis</i> + Sewer rat	Vector	<i>Yersinia pestis</i>	Facilitates bubonic plague transmission	0

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Moreira¹ and Leandro Marcio Moreira^{1,2#}

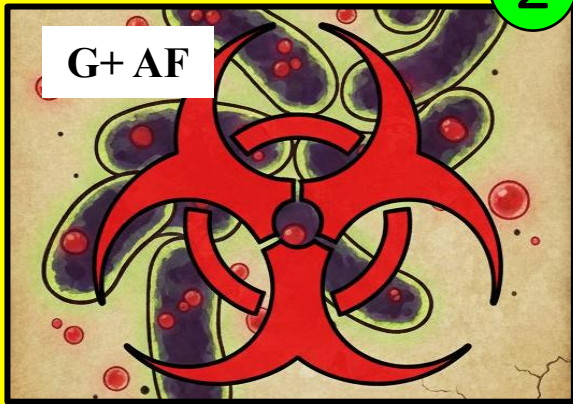
Supplementary File 1:

Game cards for printing.



Bacillus anthracis

2

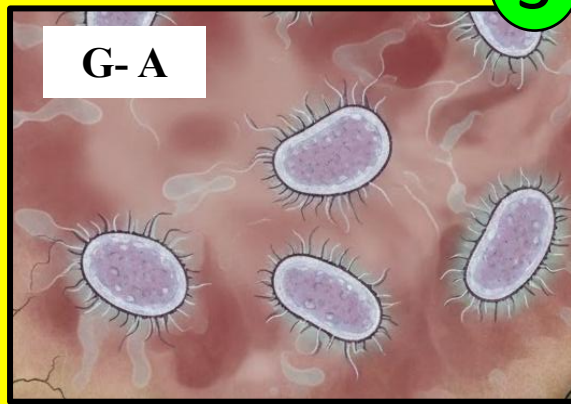


4

Infects via inhalation or spores; potent attack card

Bordetella pertussis

3

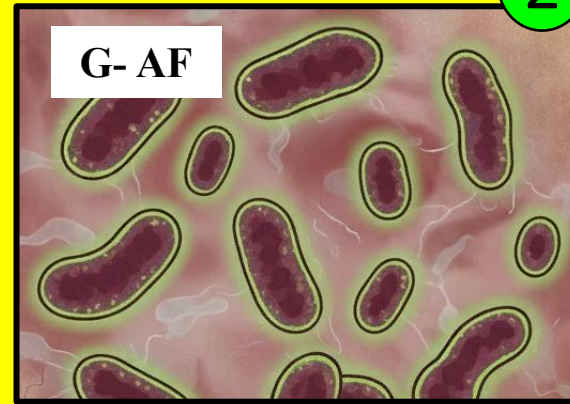


3

Spread via droplets; damages opponent when used with "Spittle"

Brucella sp.

2



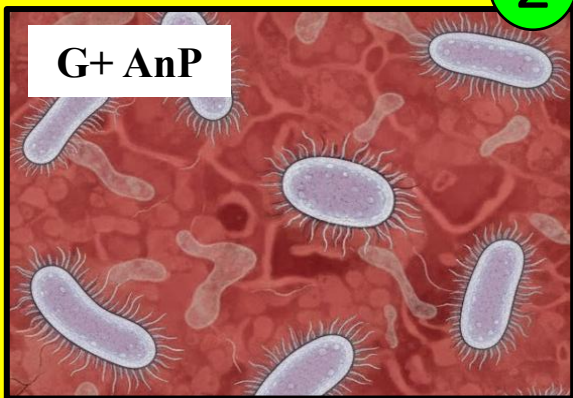
2

Spread via contaminated meat or vectors



Clostridium botulinum

2

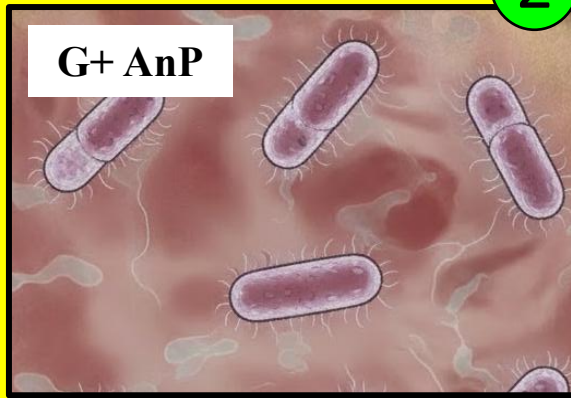


5

Entry via contaminated food; potent toxin card

Clostridium perfringens

2

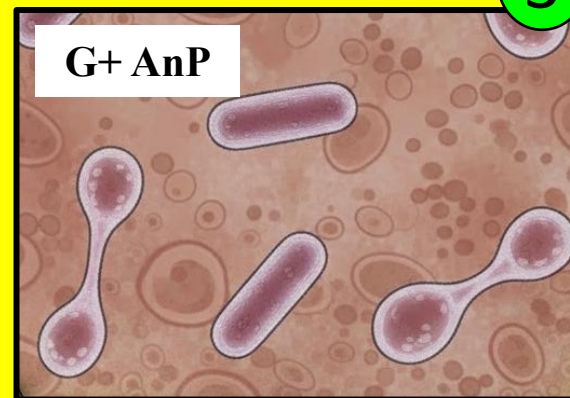


2

Entry via wounds; damages opponent if combined with "Deep Wounds"

Clostridium tetani

3



4

Requires anaerobic wounds; damages over rounds

Corynebacterium diphtheriae

1

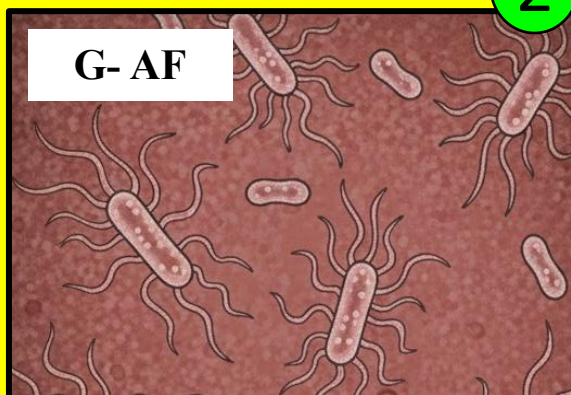


2

Attack enhanced by "Lisogenic phage"; associated with throat infection

Escherichia coli

2



3

Can become pathogenic via "Biological risk" card

Helicobacter pylori

1

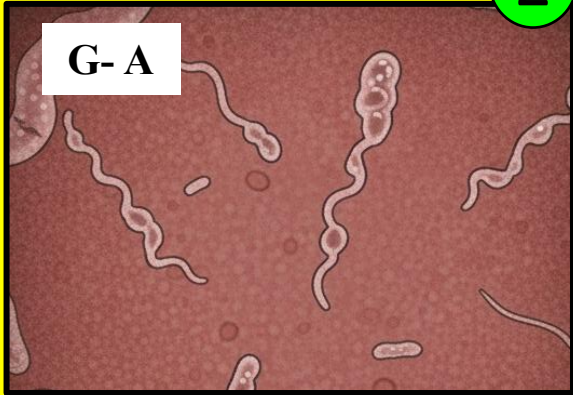


3

Colonizes stomach; damage increased by "Stress"

Leptospira interrogans

2

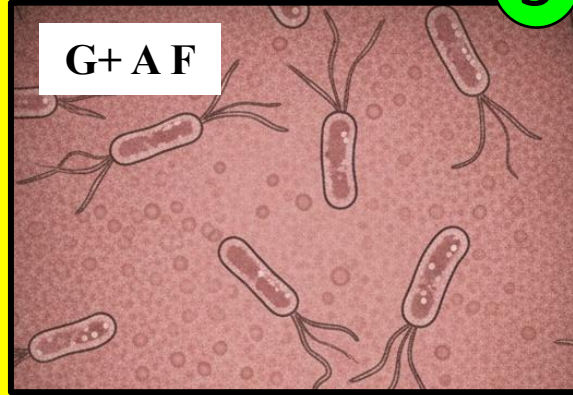


Spread via rats and
vectors

4

Listeria monocytogenes

3

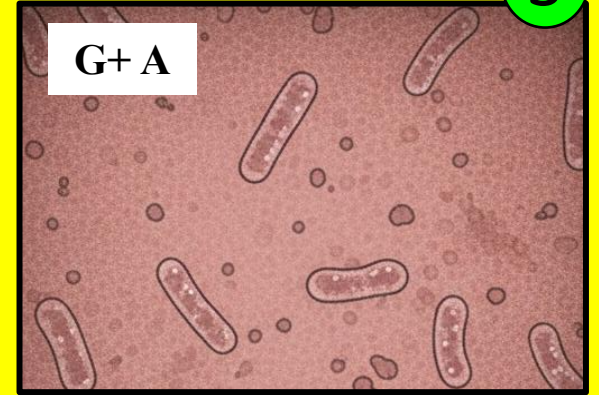


Enhanced by
“Pregnancy” card; food-
borne

4

Mycobacterium tuberculosis

3

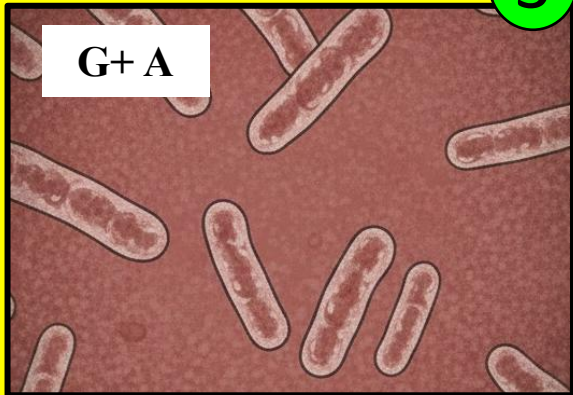


Targets lungs; defended
by neutrophils or
macrophages

2

Mycobacterium leprae

3

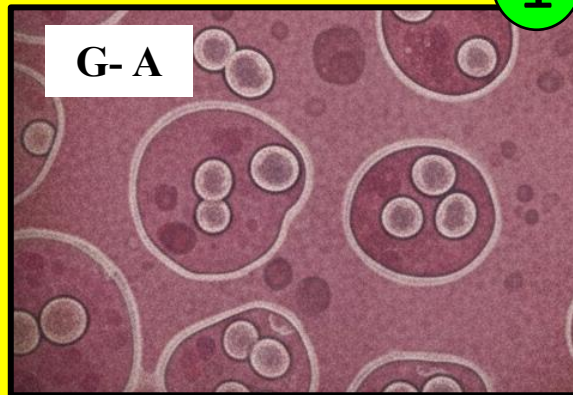


Entry via open wounds;
chronic infection card.

3

Neisseria gonorrhoeae

1

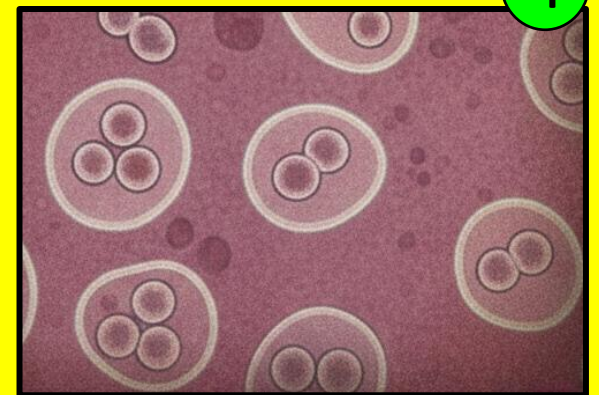


Sexual transmission;
attack card.

2

Neisseria meningitidis

4



Spread via droplets;
enhanced by “Spittle”

4

Rickettsia prowazekii

1



Vector-borne;
transmitted by lice.

2

Rickettsia rickettsii

3



Vector-borne;
transmitted by ticks.

4

Rickettsia typhi

2



Transmitted by *Pediculus
humanus*.

4

Salmonella

2

G- AF



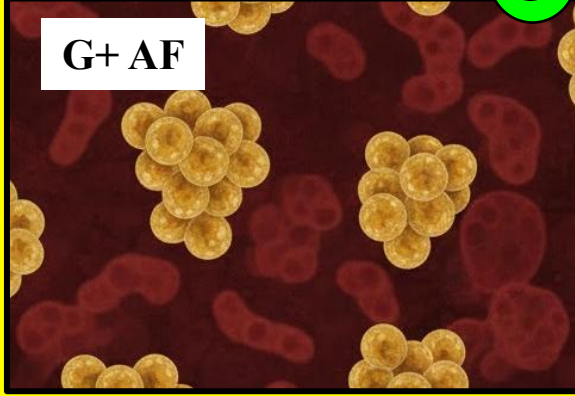
3

Food-borne; entry enhanced by "Contaminated meat" or "Unpasteurized milk".

Staphylococcus aureus

3

G+ AF



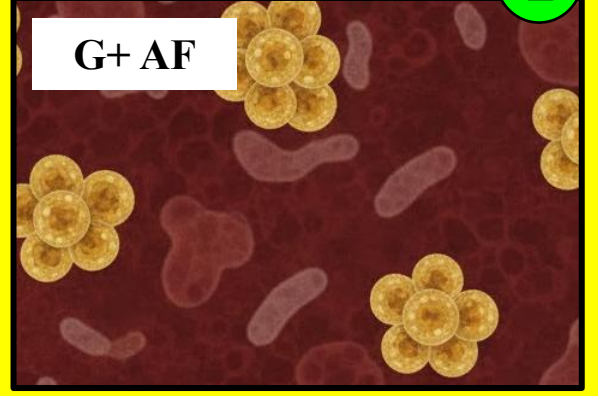
3

Entry via wounds; attack card.

Staphylococcus saprophyticus

1

G+ AF



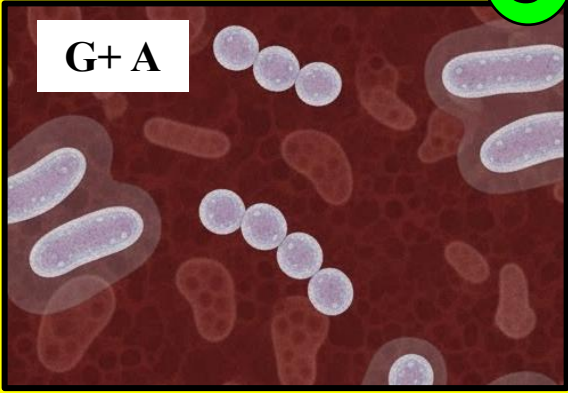
2

Sexual transmission; damage card.

Streptococcus pneumoniae

3

G+ A



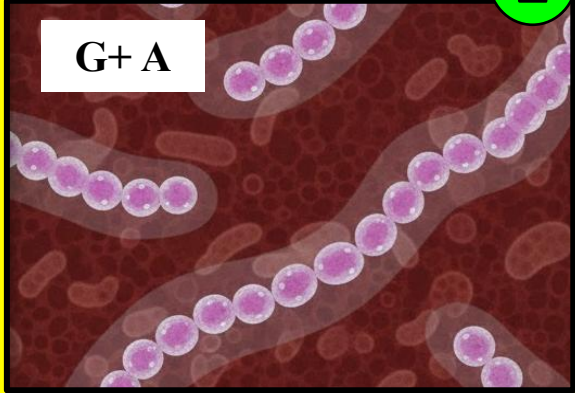
3

Respiratory pathogen; combined with droplets.

Streptococcus pyogenes

2

G+ A



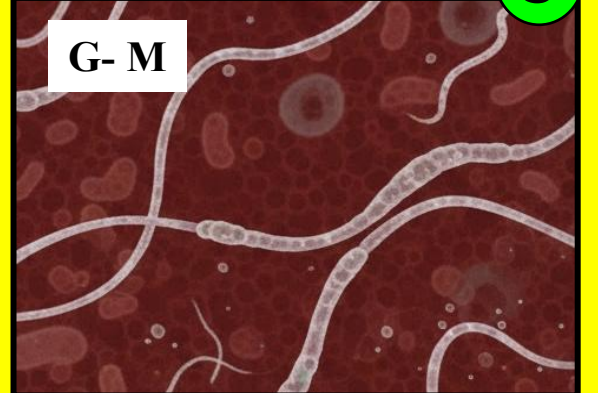
2

Entry via wounds; attack enhanced by throat infection.

Treponema pallidum

3

G- M



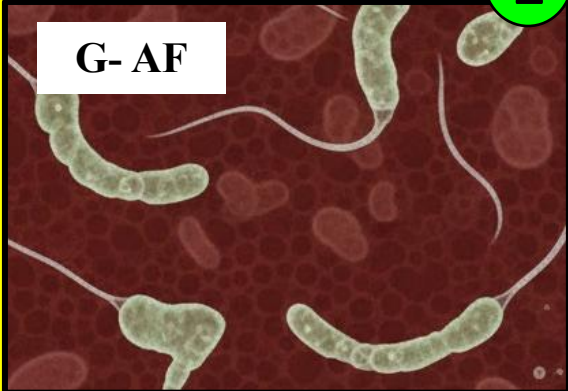
2

Sexual transmission; attack card.

Vibrio cholerae

1

G- AF



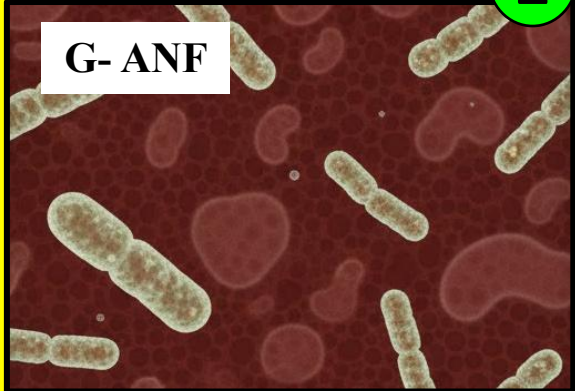
3

Food/water transmission; strong damage card.

Yersinia pestis

2

G- ANF



4

Vector-borne; enhanced via rat and flea cards

Anaerobic environment

2



Aerobic bacteria in attack. Kills all aerobic bacteria; prevails over defense cards.

Aerobic environment

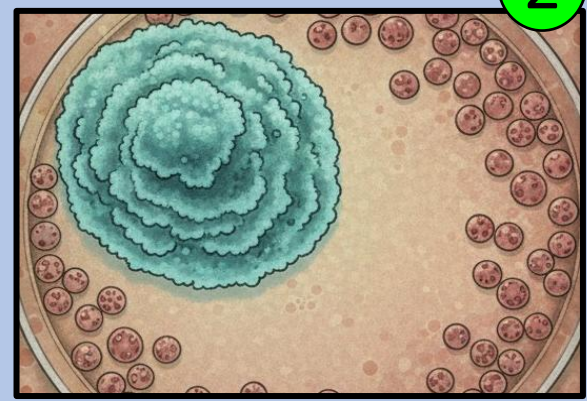
2



Anaerobic bacteria in attack. Kills all anaerobic bacteria; prevails over defense cards.

Penicillin

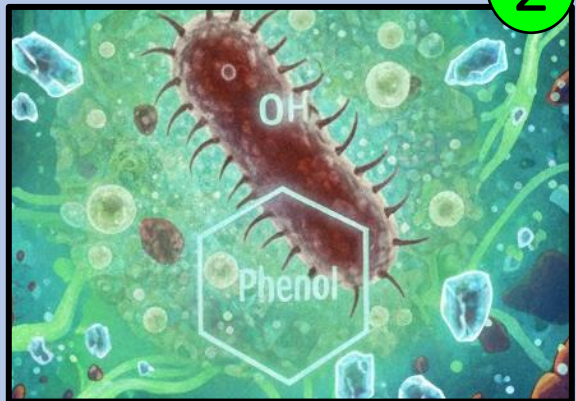
2



Treponema pallidum and *Streptococcus pyogenes*. Destroys bacterial colonies of target pathogens.

Phenol (carbolic acid)

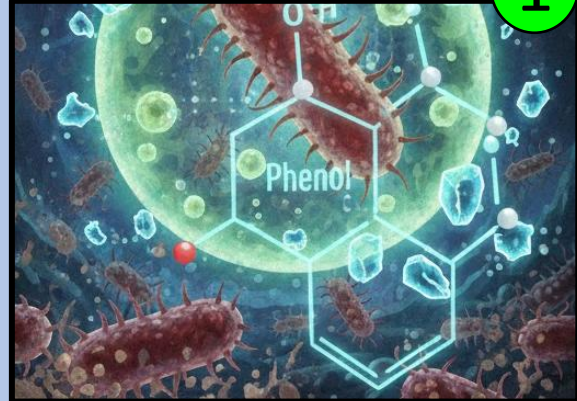
2



Mycobacterium leprae and *Mycobacterium tuberculosis*. Used with "1%" card to neutralize attacking bacteria.

Biphenols (hexachlorophene)

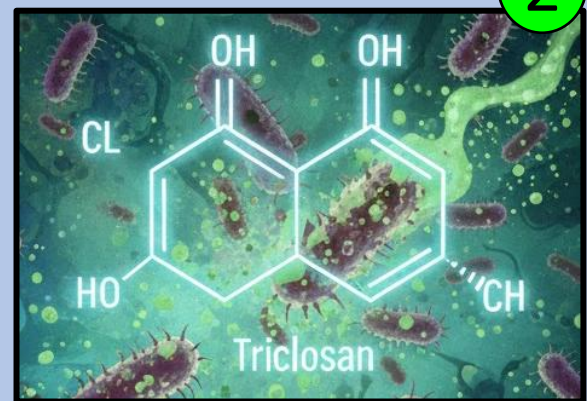
1



Gram-positive (*Streptococcus* and *Staphylococcus*). Kills targeted bacteria on attack.

Triclosan

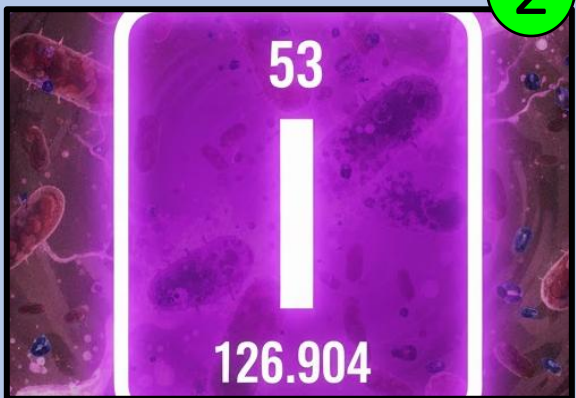
2



Gram-positive bacteria. Prevents attack for 2 rounds.

Halogens (iodine)

2



Open wound / Deep wound pathogens. Prevents pathogen entry for 1 round.

Healing ointment

1



Promotes recovery; assists immune defense.

Platelets

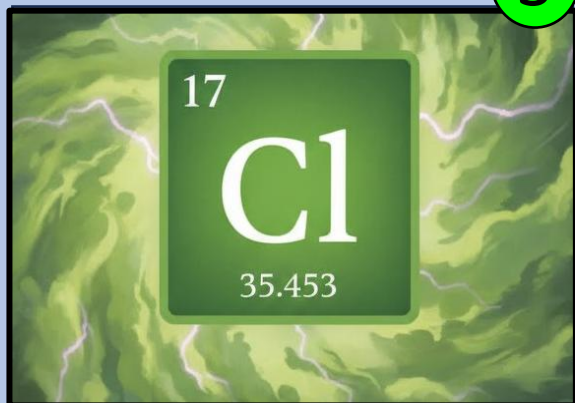
1



Supports defense against attacking bacteria.

Chlorine

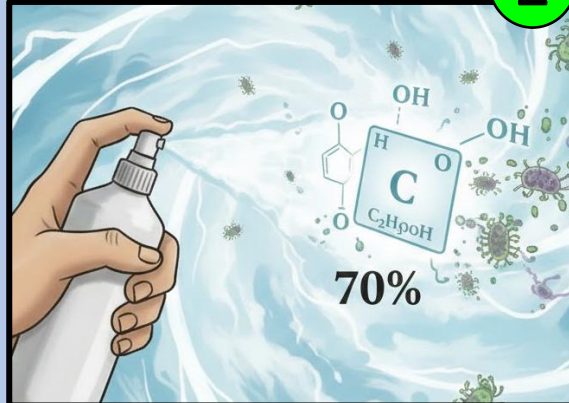
3



Water-borne bacteria.
Protects individual for 2
rounds when combined
with “Water” card.

Alcohol 70%

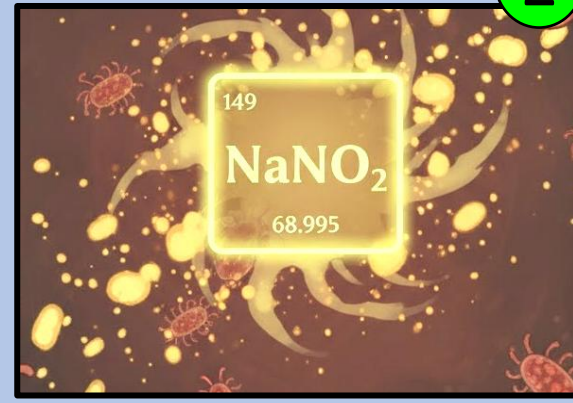
2



All bacteria. Protects
individual for 1 round.

Sodium nitrite

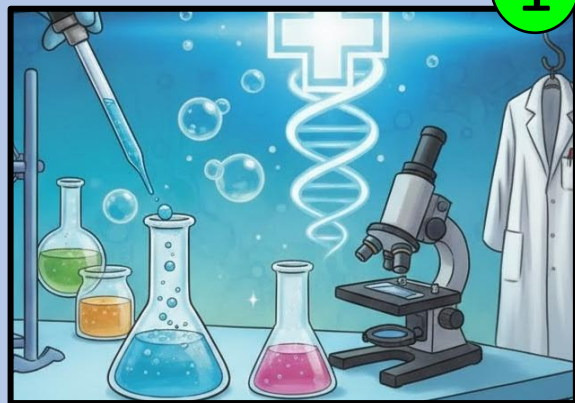
2



Bacteria in
“Contaminated meat”.
Neutralizes attack;
bacteria return to deck.

Research and treatment

1



Attacking bacteria.
Paralyzes attack for 2
rounds.

Quaternary ammonium compounds

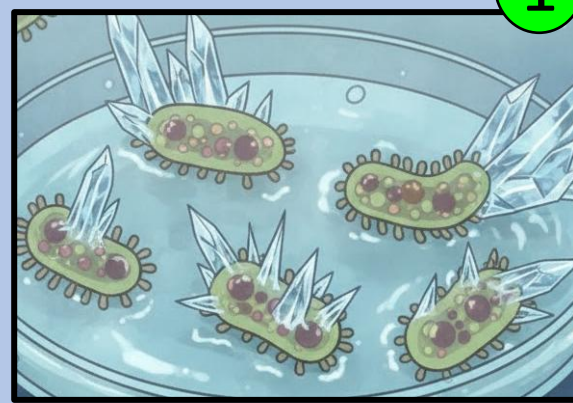
2



Throat infection bacteria
(except *Pseudomonas*).
Neutralizes attacks for 2
rounds; less effective in
organic matter.

Slow freezing

1



Attacking bacteria. Kills
bacteria after 3 rounds
via crystal formation.

Fast freezing

1



Attacking bacteria.
Paralyzes attack for 2
rounds; does not kill.

Autoclave

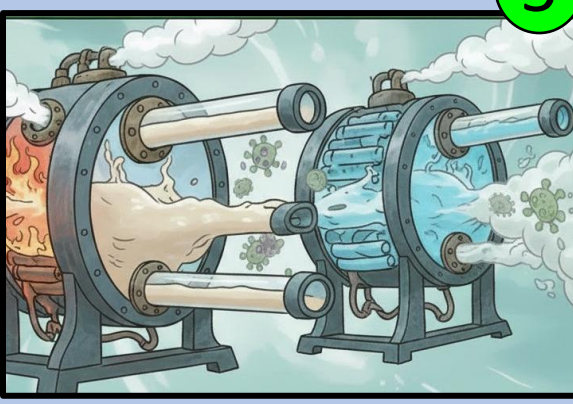
2



All attacking bacteria.
Kills all bacteria;
requires “15 min” card.

Pasteurization

5



All attacking bacteria.
Kills bacteria from
attacking opponent.

Vitamin C

2



Macrophages /
Neutrophils. Increases
destructive power
against 2 bacteria.

Neutrophil

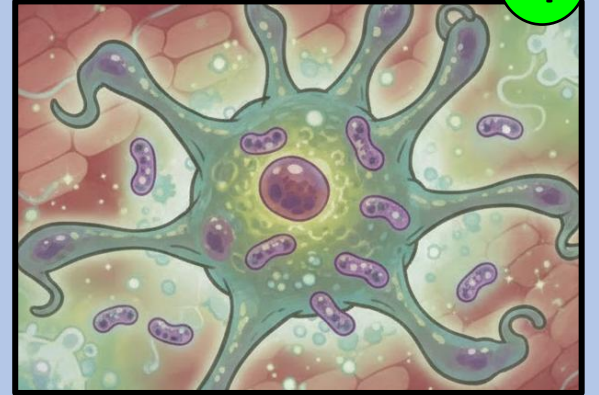
2



1 bacterium in attack.
Kills bacteria; enhanced
with Vitamin C / T4
lymphocytes.

Macrophage

4



1 bacterium in attack.
Kills bacteria; enhanced
with Vitamin C / T4
lymphocytes.

Aniquilating Serpent

2



Rats transmitting
plague. Removes rat
cards from play; returns
to deck.

Poison against lice and ticks

3



Lice / ticks. Eliminates
vector cards; returns
them to deck.

Care in sexual relations

1



Sexually transmitted
pathogens. Protects for
2 rounds.

Decomposer bacteria

2



Food-borne bacteria.
Removes multiplying
bacteria from table.

Health surveillance

0



Food-borne bacteria.
Eliminates pathogens
causing foodborne
illness.

Physical exercises

2



1 bacterium. Increases
immune cell attack
power.

Keep calm

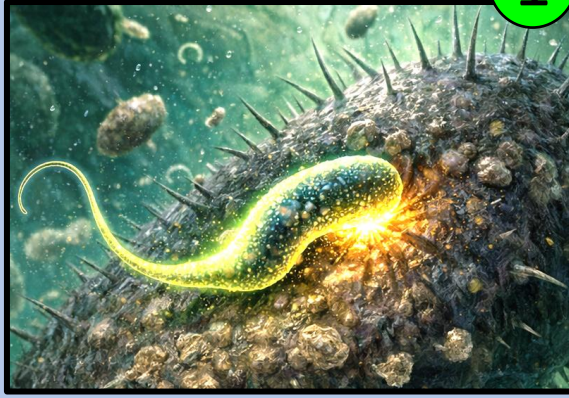
1



Stress card. Neutralizes
“Stress” effect.

Bedellovibrio

1



1 Gram-negative
bacterium. Kills targeted
bacterium.

Medical prescription

2



Enhances action of
antibiotics cards.

DPT vaccine

0



Diphtheria, Pertussis,
Tetanus bacteria.
Provides immunity to
targeted pathogens.

Water

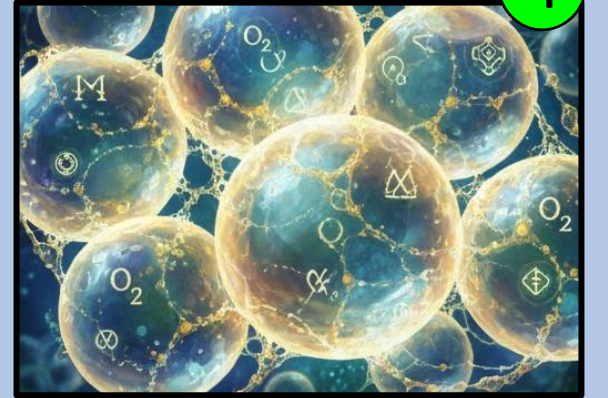
1



Chlorine card. Activates
chlorine effectiveness
against bacteria.

Surfactant

4



Surface pathogens /
biofilms. Reduces
pathogen adhesion;
blocks attack for 1
round.

Bacterial transformation

2



Attacking bacteria.
Increases genetic
variability; evades
antibiotic action.

Bad eating habits

1



Host immune cells.
Reduces macrophage
and neutrophil
efficiency.

Biological risk

2



Commensal bacteria.
Converts commensals
into pathogens.

Blood flow

0



Parasites / vectors.
Allows direct entry of
blood-borne pathogens.

Conjugation

2



Attacking bacteria.
Enhances variability;
avoids antibiotics (except
autoclave, pasteurization
and surfactant).

Contaminated meat

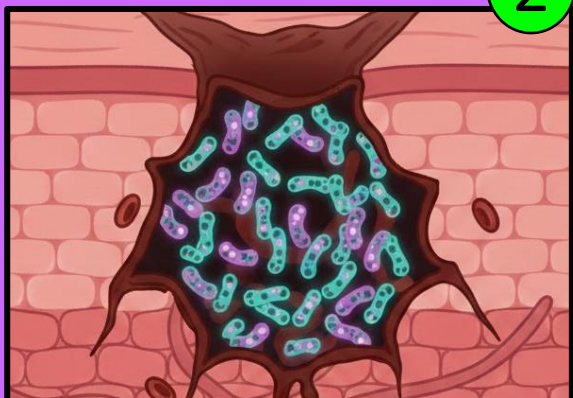
1



Food-borne pathogens.
Carries multiple
pathogens; enables
transmission.

Deep wounds

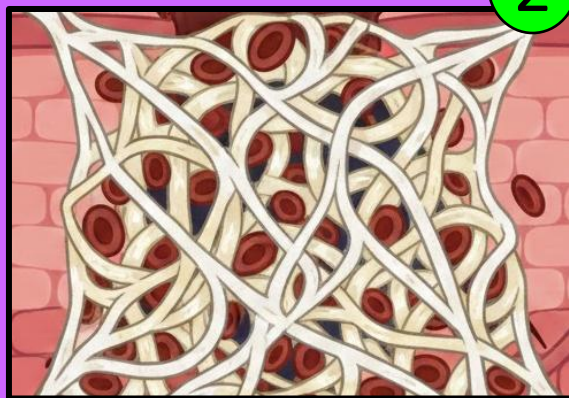
2



Severe bacterial
pathogens. Enables
high-damage infections.

Fibrin

2



All bacteria. Increases
pathogen damage.

Inhalation of spores

0



Bacillus anthracis.
Enables infection via
respiratory route.

Kidney dysfunction

0



Streptococcus. Induces nephritis if combined.

Lysogenic phage

2



Corynebacterium.
Potentiates bacterial attack.

Open wounds

2



Various bacteria.
Enables pathogen entry.

Pediculus humanus

0



Rickettsia typhi.
Facilitates endemic typhus transmission.

Pregnancy

1



Listeria monocytogenes
and *Neisseria meningitidis*. Increases damage when associated.

Rheumatic fever Valve stenosis

0



Streptococcus. Causes damage points depending on combination.

Spittle

1



Respiratory pathogens.
Enhances pathogen spread.

Spore intake

1



Bacillus anthracis and
Salmonella spp.
Reintroduces bacteria;
simulates rapid proliferation.

Star tick bite

0



Rickettsia rickettsii.
Facilitates Rocky Mountain spotted fever transmission.

Stress

1



Pathogens. Increases damage caused by pathogens.

Throat infection

1



Streptococcus. Boosts attack if combined with relevant cards.

Unpasteurized milk

2



Food-borne bacteria. Reintroduces bacteria up to 3 times; simulates rapid proliferation.

Xenopsylla cheopis +
Sewer rat

0



Yersinia pestis.
Facilitates bubonic plague transmission.

Game-Based Learning in Microbiology Education: Design and Classroom Use of *MicroBioCombat*

Raul Vinicius Salata Souto¹, Edmara Rocha dos Santos Moreira¹
and Leandro Marcio Moreira^{1,2#}

Supplementary File 2: Scoring table for printing.

Vital Energy Table

MicroBioCombat

Round	Points	Activities	Other observations
1	20		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			