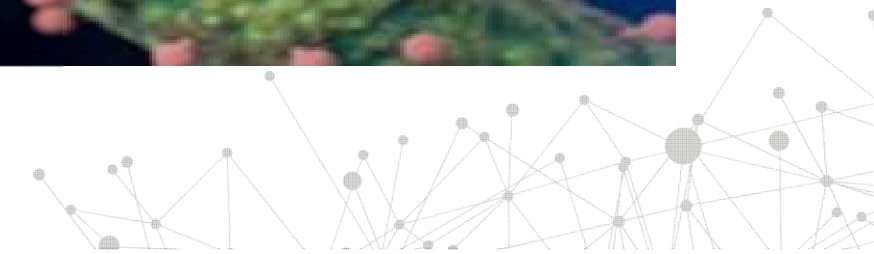
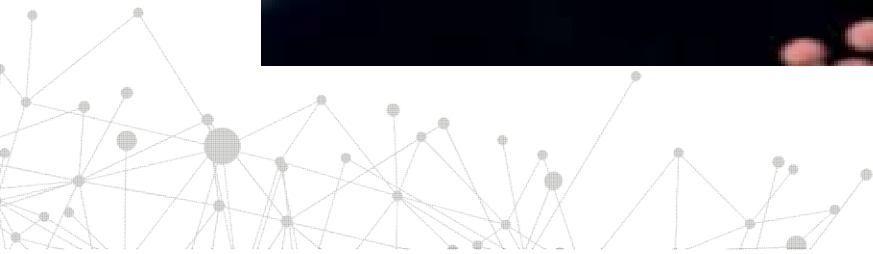
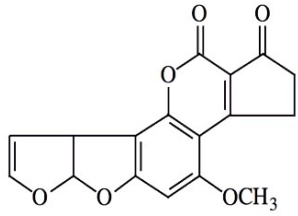


BACTERIOPHAGES

**A REASONABLE
ALTERNATIVE
TO
ANTIBIOTICS**

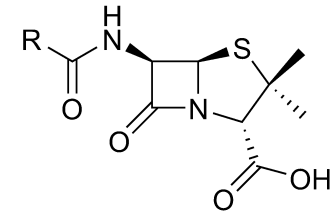
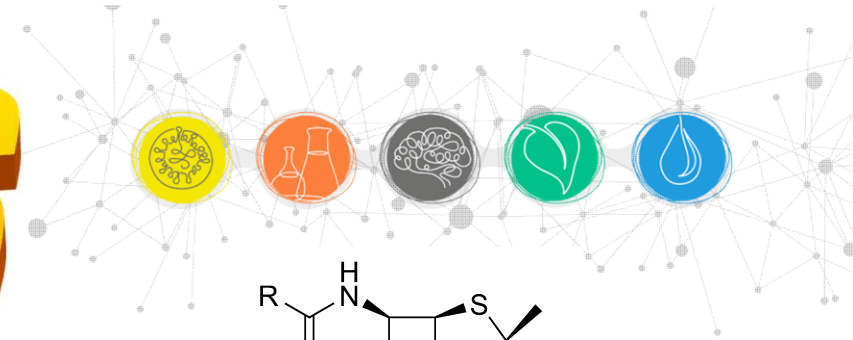
RICHARD D. MILES
PROFESSOR EMERITUS
UNIVERSITY OF FLORIDA





AFLATOXIN B₁

MYCOTOKINS



PENICILLIN

...SIMPLY STATED...

THEY ARE TOXIC MOLECULES PRODUCED BY FUNGI

.....WITH ONLY ONE PURPOSE.....

**ANTI-BACTERIAL
ANTI-PROTOZOAN
ANTI-VIRAL**

TO KILL

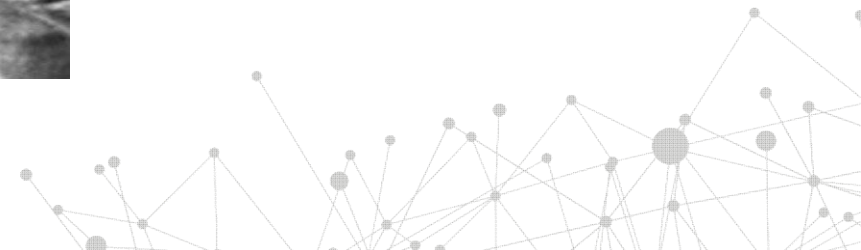
**ANTI-INSECT
ANTI-FOOD ANIMAL
ANTI-HUMAN**

ANTIBIOTICS



SIR ALEXANDER FLEMING

RECEIVED CREDIT FOR DISCOVERY OF PENICILLIN
IN 1928 WHILE AT ST. MARY'S HOSPITAL IN LONDON, ENGLAND



ANTIBIOTICS



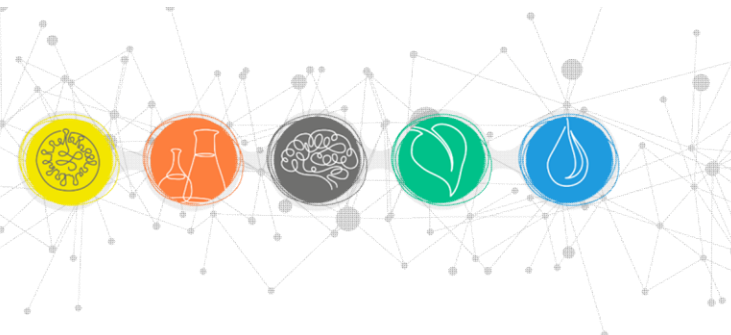
...GIVING CREDIT WHERE CREDIT IS DUE...



DR. CLODOMIRO PICADO TWIGHT

**DOCUMENTED THE DISCOVERY OF PENICILLIN
IN HIS LABORATORY NOTEBOOKS (1915-1927)
AND PUBLISHED HIS RESULTS IN 1927**

ANTIBIOTICS



TWO MAJOR REASONS FOR THE USE OF ANTIBIOTICS IN ANIMALS

GROWTH ENHANCEMENT/PROMOTION

PROVIDED TO HEALTHY ANIMALS AT DIETARY CONCENTRATIONS
OF BELOW 200 GRAMS PER TON OF FEED FOR MORE THAN 14 DAYS

THERAPEUTIC AND PROPHYLACTIC USE

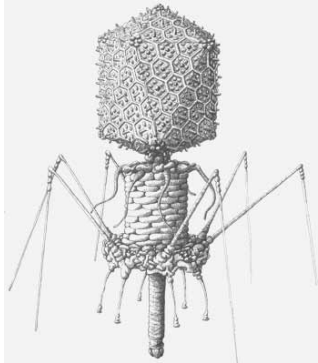
PROVIDED TO ANIMALS TO TREAT OR PREVENT INFECTION/DISEASE



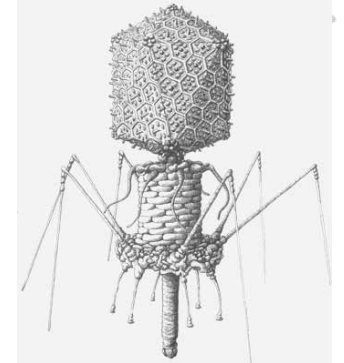
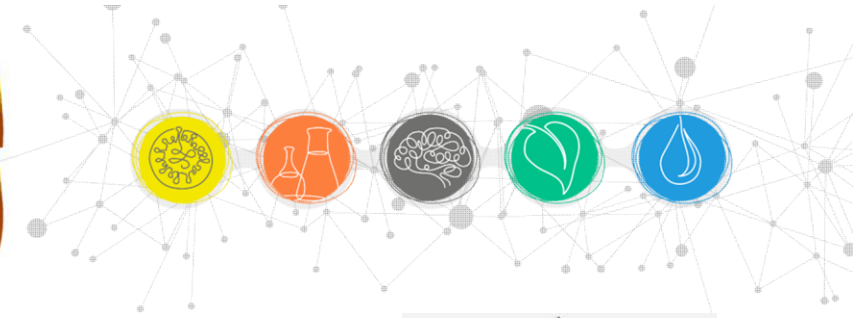
Dr. Twilight



Dr. Twilight

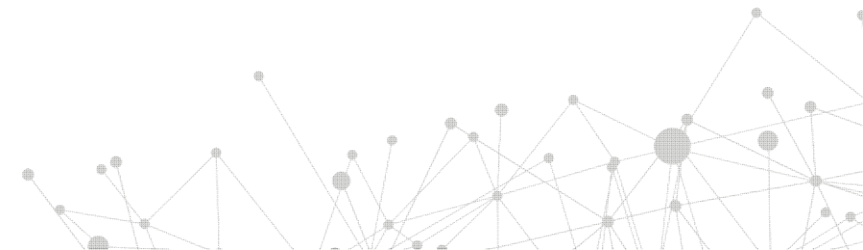


BACTERIOPHAGES



...SIMPLY STATED...
THEY ARE VIRAL ASSASSINS
WITH ONLY TWO PURPOSES
.....FOR THEIR EXISTENCE.....

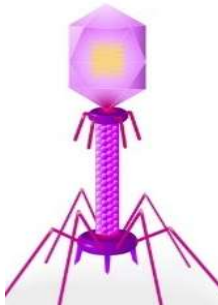
**TO KILL BACTERIA
AND
REPLICATE**



WHEN WERE BACTERIOPHAGES DISCOVERED AND BY WHOM ?



1896
ERNEST HANKIN
ENGLISH BACTERIOLOGIST



GANGES RIVER: CURE FOR CHOLERA

QUESTION

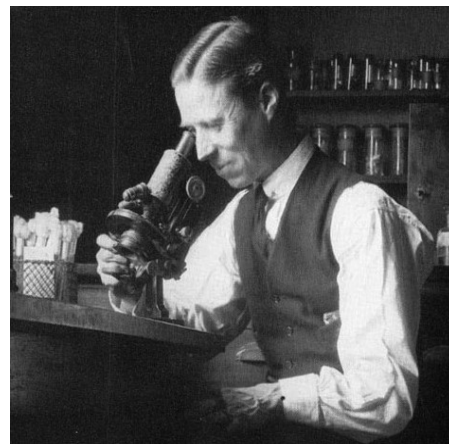
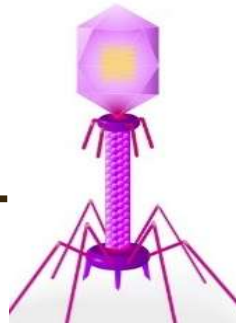
WHO DOCUMENTED THE ANTI-BACTERIAL NATURE OF PHAGES



1915

FREDERICK WILLIAM TWORT

ENGLISH BACTERIOLOGIST

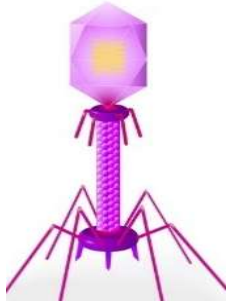


**...HOWEVER...
DID NOT KNOW
THE MECHANISM OF
BACTERIAL DESTRUCTION**

QUESTION



**WHO IS CREDITED WITH ISOLATING
BACTERIOPHAGES AND DISCOVERING
THAT BACTERIOPHAGES ARE
RESPONSIBLE FOR KILLING BACTERIA ?**

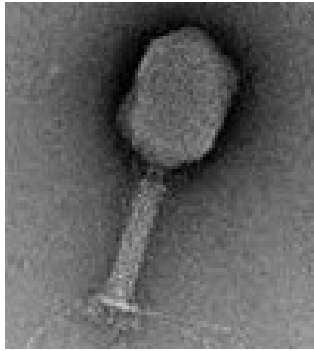


1917
FELIX d' HERELLE
FRENCH-CANADIAN
MICROBIOLOGIST

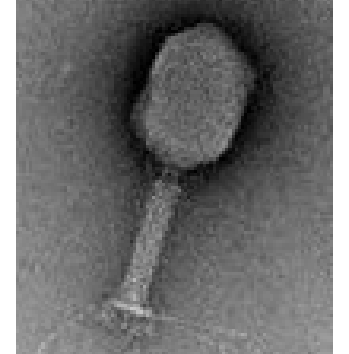
**HE PROPOSED “PHAGE THERAPY”
AND THE USE OF PHAGE COCKTAILS
TO TREAT BACTERIAL DISEASES**

QUESTION



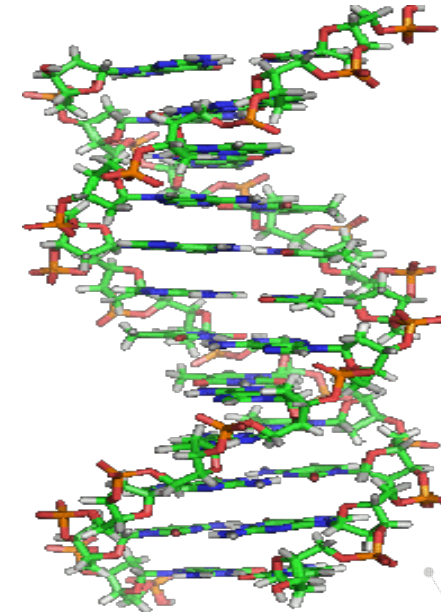
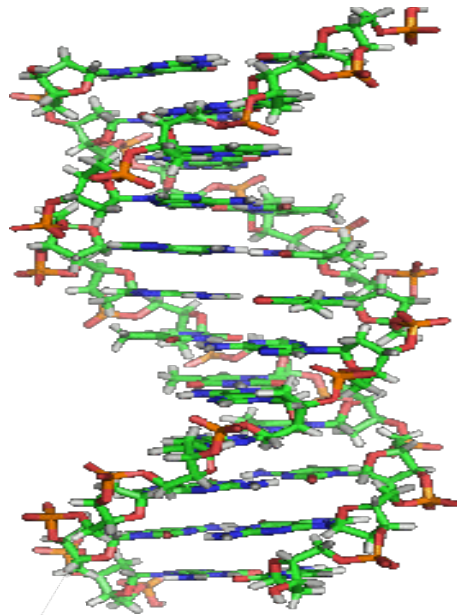


BACTERIOPHAGE

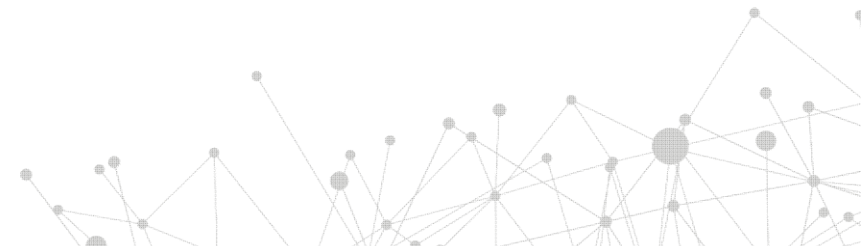
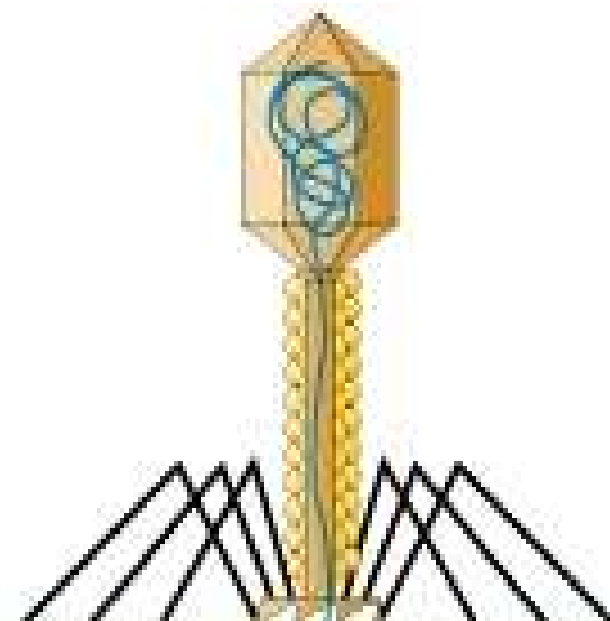
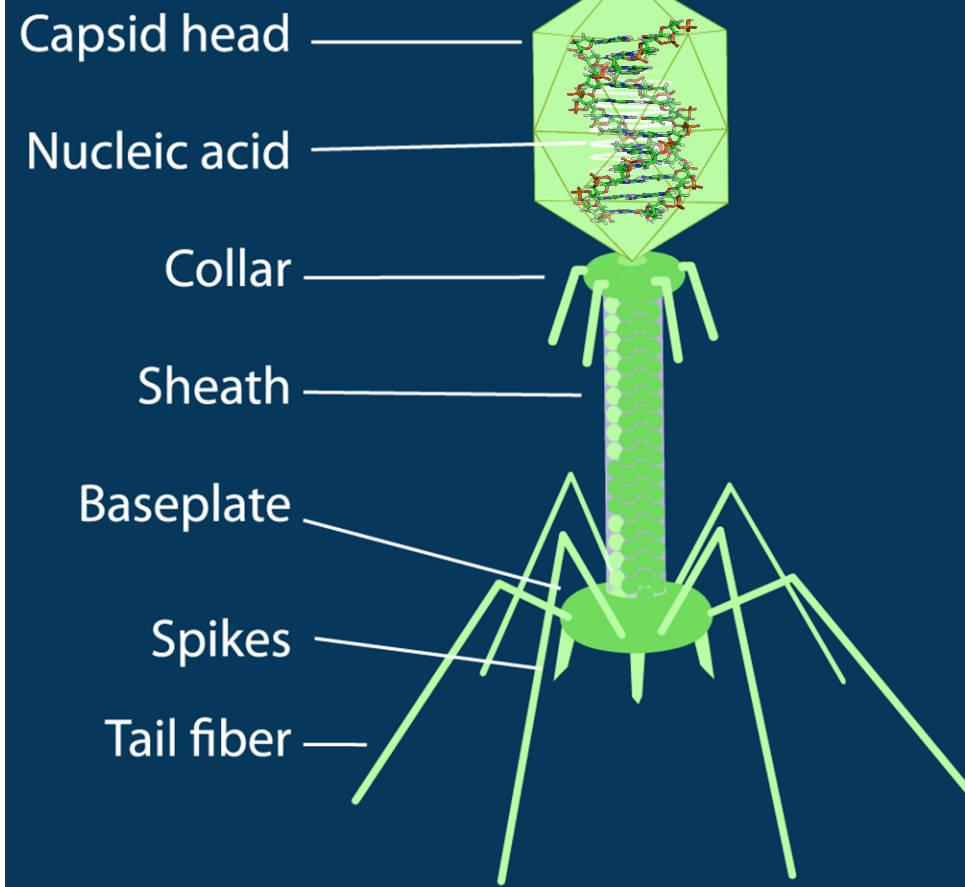
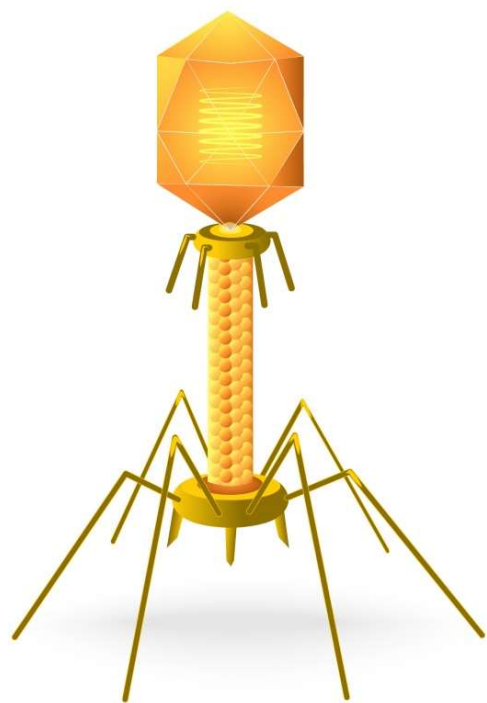


...FACTS...

ARE THE MOST ABUNDANT/DIVERSE FORM OF DNA REPLICATING AGENT ON OUR PLANET



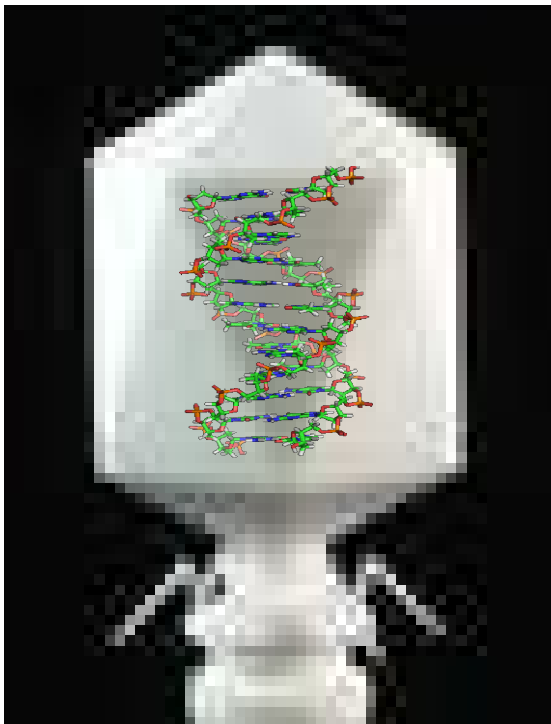
STRUCTURE



FACTS



**ARE THE MOST ABUNDANT/DIVERSE
FORM OF DNA REPLICATING AGENT ON OUR PLANET
(TODAY: PHAGES CAN BE NATURAL OR ENGINEERED)**



HEADSIZE

~ 25-100 nm

**DEPENDING ON HOW MUCH
DNA OR RNA IS PRESENT**

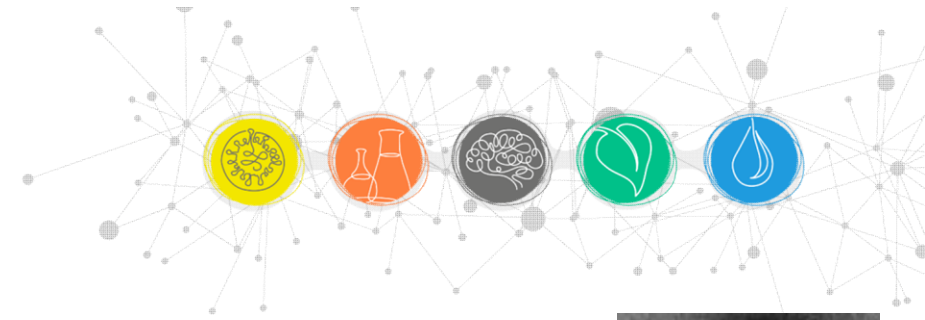
...AND...

**THE GENOME MAY CONTAIN
AS FEW AS 4 GENES**

OR

SEVERAL HUNDRED GENES

FACTS



DO NOT MOVE INDEPENDENTLY

(NO MEANS OF MOBILITY)

DO NOT INFECT ANIMAL OR PLANT CELLS

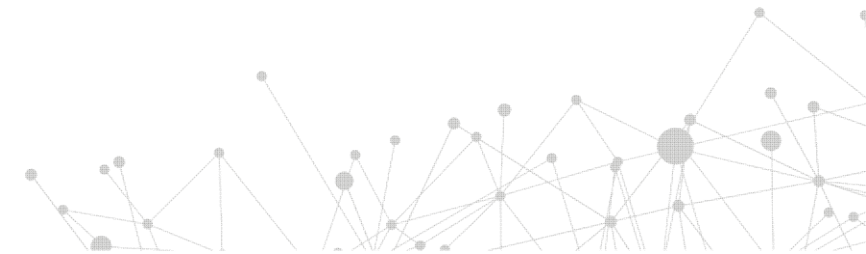
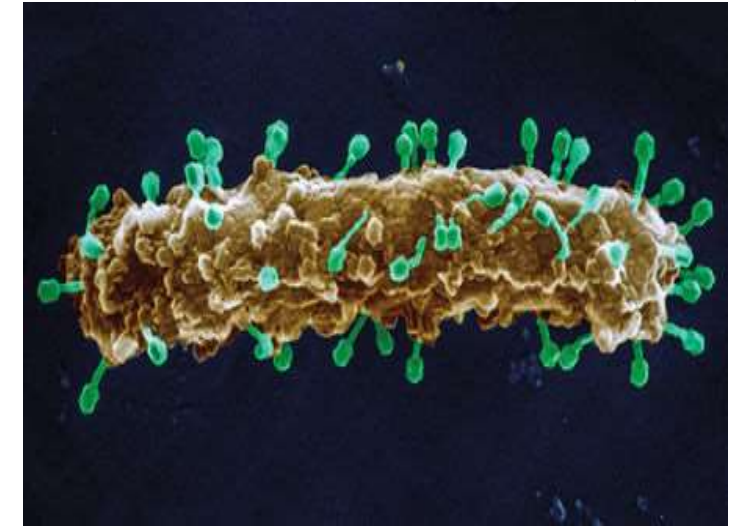
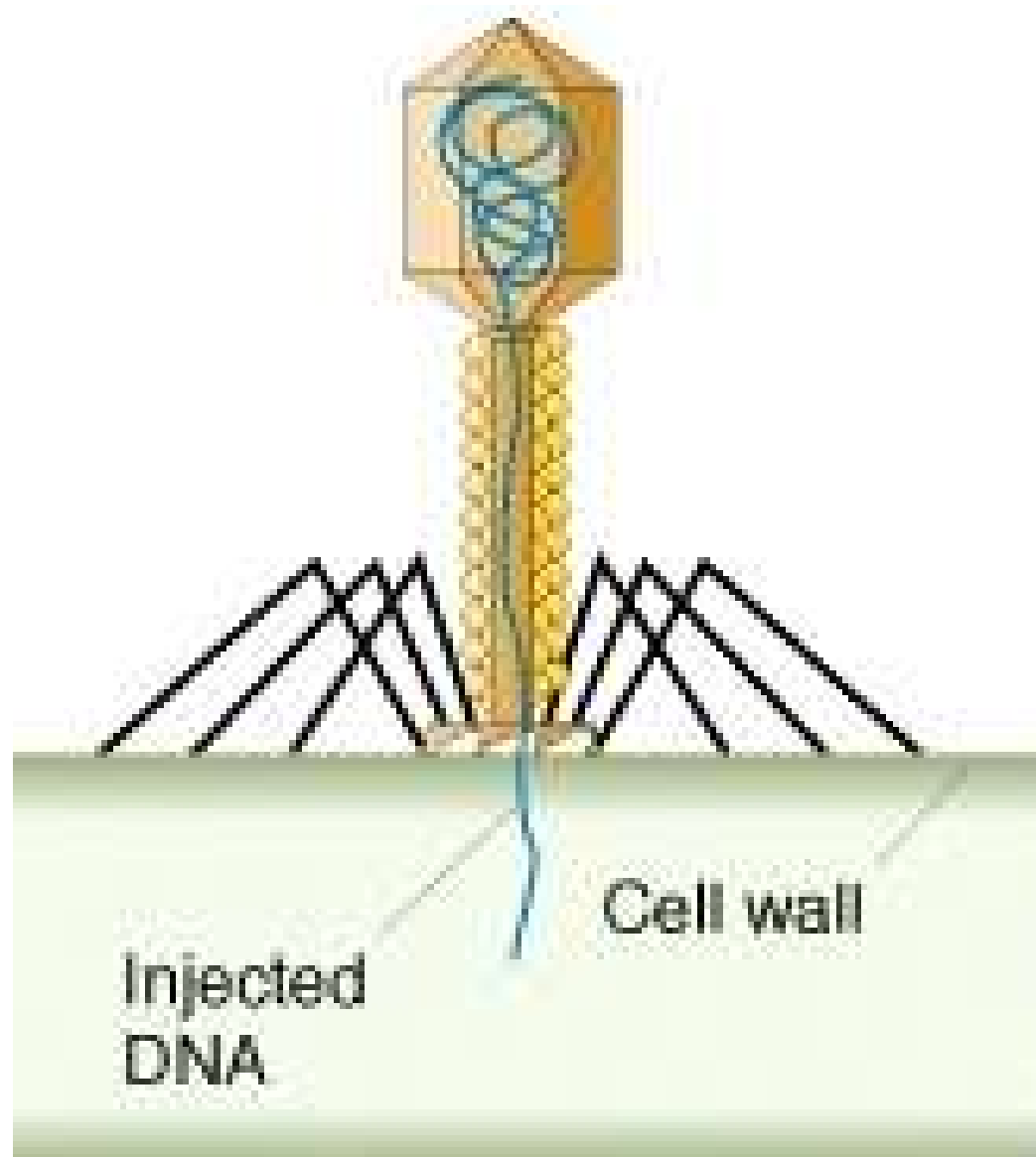
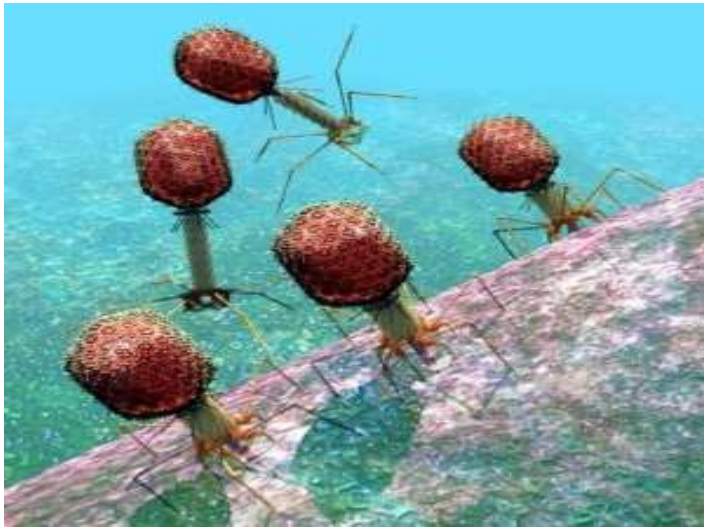
(BACTERIA SPECIFIC)

DO NOT HAVE ANY ORGANELLS

(NUCLEUS, RIBOSOMES, MITOCHONDRIA, ENDOPLASMIC RETICULUM, ETC.)

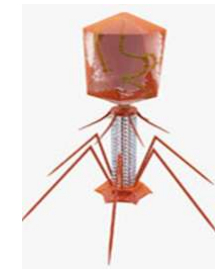
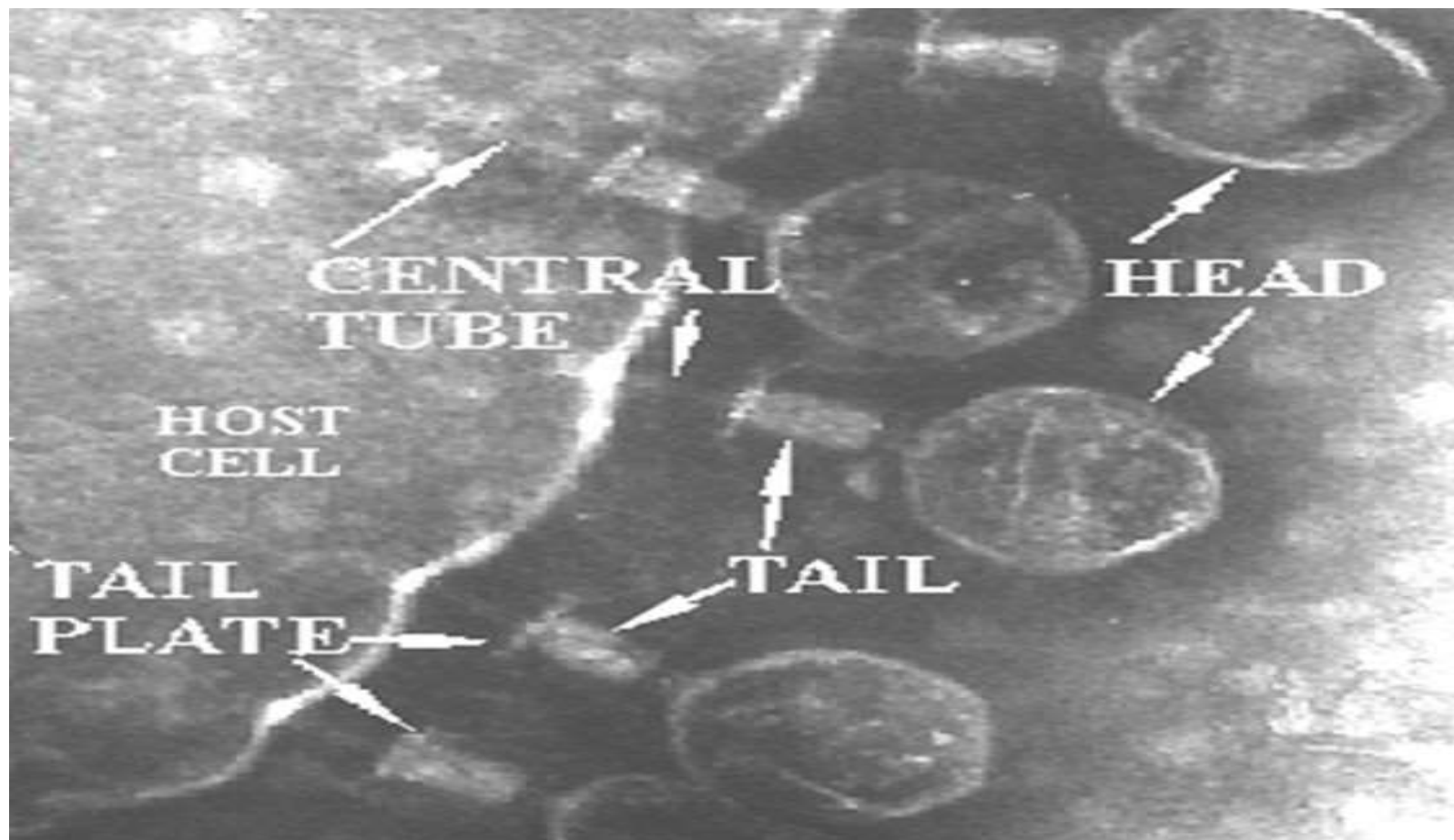
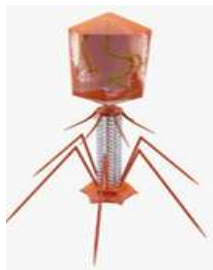
DO NOT HAVE ANY METABOLIC PATHWAYS

(THEREFORE, CANNOT METABOLIZE NUTRIENTS AND GENERATE ATP)

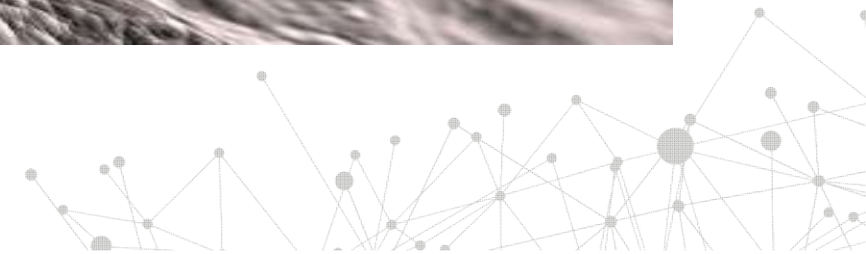
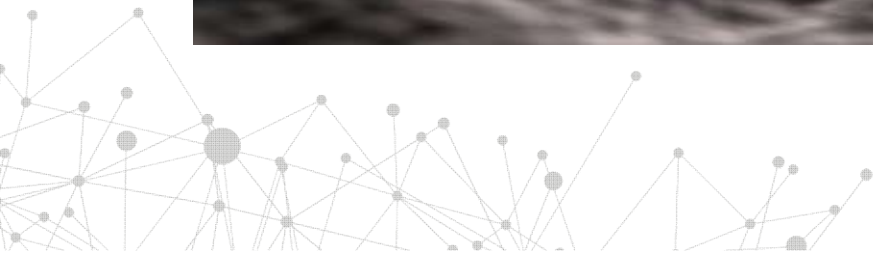
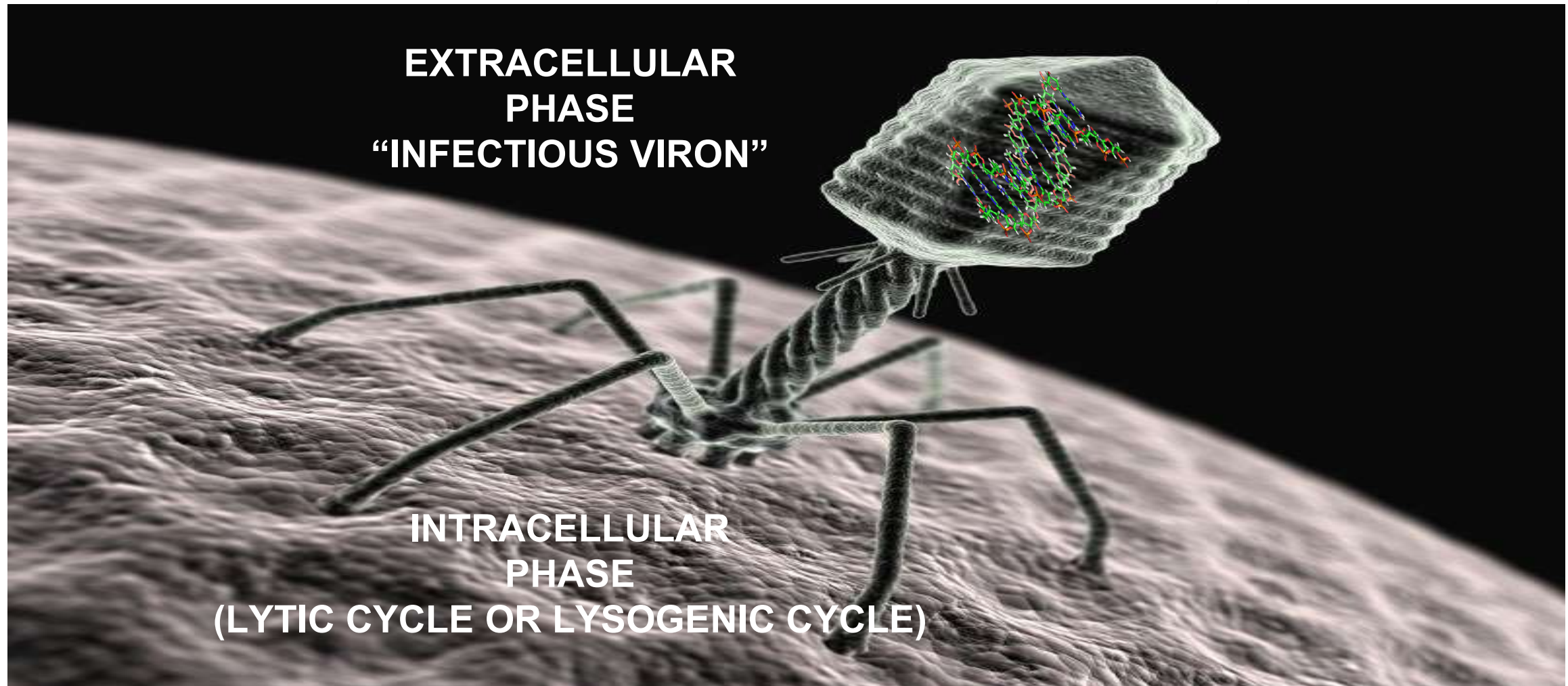


BACTERIOPHAGE

BINDING TO BACTERIA AND INJECTING DNA



“LIFE CYCLE”



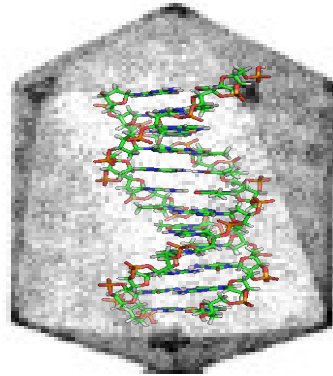
“LIFE CYCLE”



INTRACELLULAR PHASE

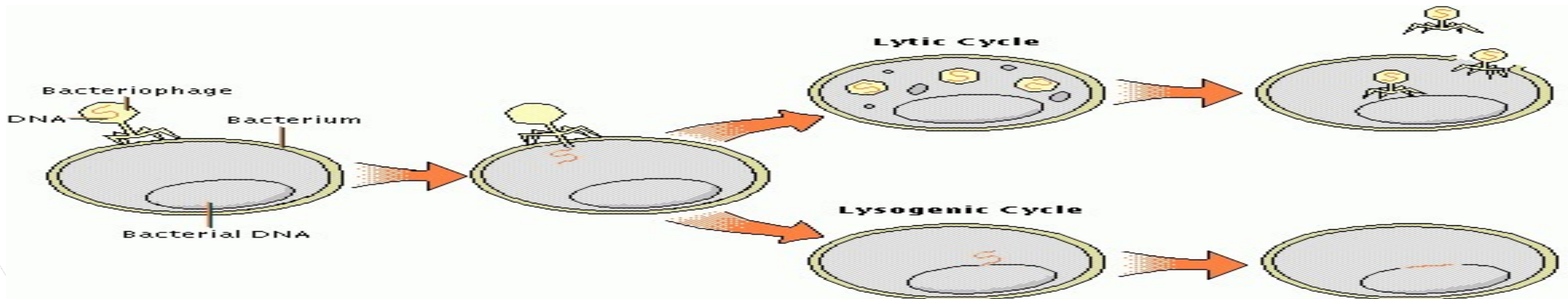
LYTIC CYCLE

**GENETIC MATERIAL
 INJECTED INTO BACTERIA
 REPLICATED IN BACTERIA
 NEW PHAGES FORMED
 BACTERIAL CELL BURSTS (LETHAL)**



LYSOGENIC CYCLE

**GENETIC MATERIAL
 INJECTED INTO BACTERIA
 STORED IN BACTERIAL DNA
 REMAINS DORMANT (NON-LETHAL)
 (EVENTUALLY RELEASED/LYTIC CYCLE ACTIVATED)**

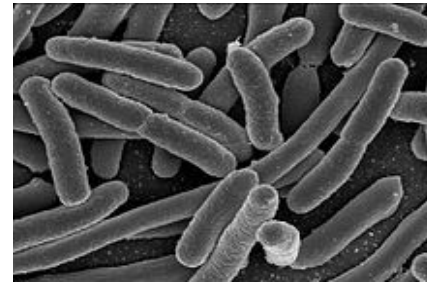


WHAT SEEMS TO CONTROL WHETHER
A LYTIC CYCLE OR A LYSOGENIC CYCLE
WILL OCCUR IN THE BACTERIA ?



CURRENT THINKING

“BACTERIOPHAGE CONCENTRATION”

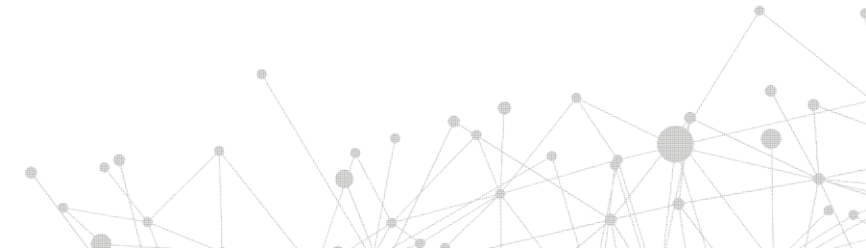


LOTS OF BACTERIA
FEW PHAGES
LYTIC CYCLE
OCCURS



LOTS OF PHAGES
FEW BACTERIA
LYSOGENIC CYCLE
OCCURS

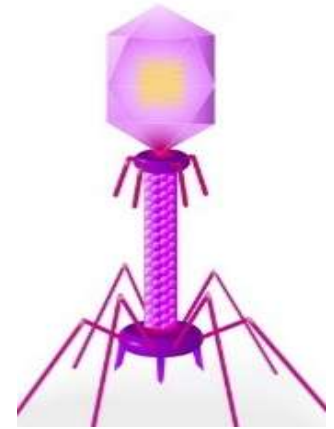
QUESTION



**WHERE CAN BACTERIOPHAGES
BE FOUND ?**



**BACTERIOPHAGES
ARE
UBIQUITOUS**



**WHERE YOU FIND BACTERIA
YOU WILL FIND
BACTERIOPHAGES**

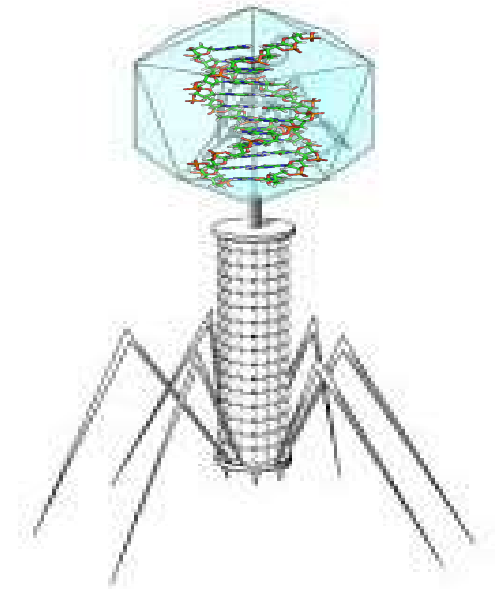
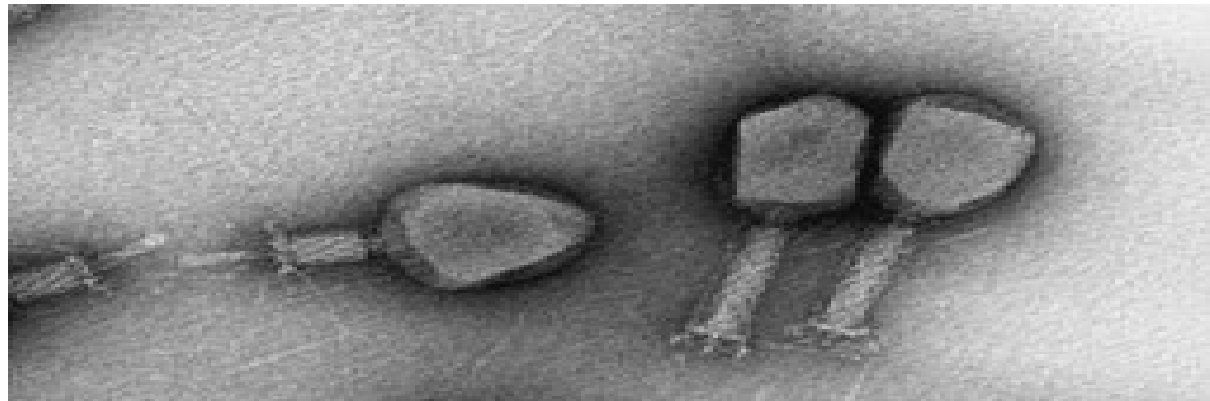
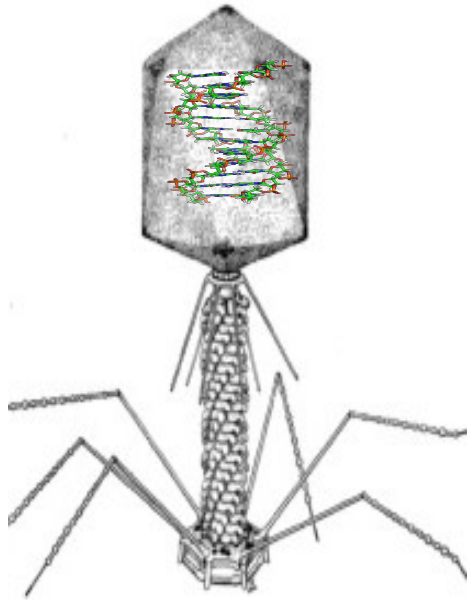
QUESTION



...FACT...



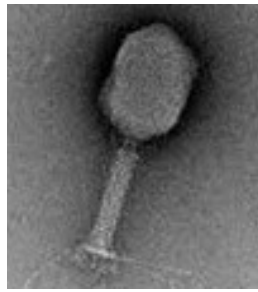
FOUND EVERYWHERE ON EARTH



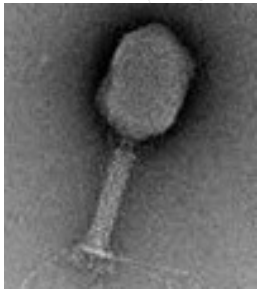
(BACTERIAL SPECIES SPECIFIC)
(NO BACTERIAL RESISTANCE DEVELOPS)
(PROVIDE NON-HOST DERIVED IMMUNITY)



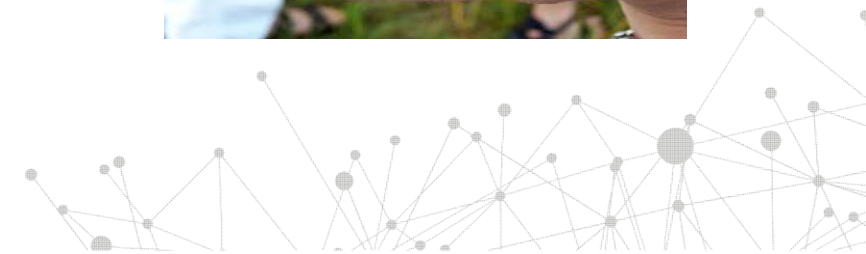
...FACT...



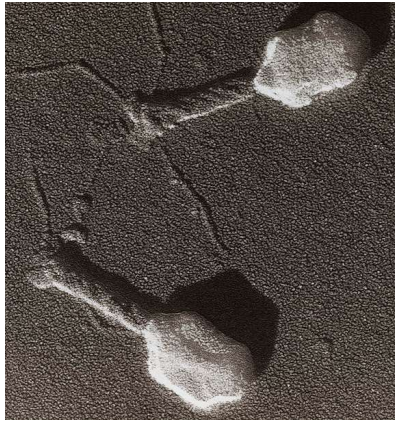
FOUND EVERYWHERE ON EARTH SEAWATER AND MICROBIAL MATS CONTAIN HIGH NUMBERS OF BACTERIOPHAGES (9×10^8 /ML)



**IT IS ESTIMATED THAT BACTERIOPHAGES DESTROY
UP TO 40% OF THE BACTERIA IN EARTH'S OCEANS DAILY**



...FACTS...



**HAVE BEEN USED FOR OVER 100 YEARS
AS AN ALTERNATIVE TO ANTIBIOTICS
IN THE FORMER SOVIET UNION,
CENTRAL EUROPE AND FRANCE**



BACTERIOPHAGE BANKS/LIBRARIES EXIST

**BACTERIOPHAGE THERAPY IS AVAILABLE TO TREAT
INFECTIOUS DISEASES CONSIDERED UNTREATABLE**

("PHAGE THERAPY CENTERS EXIST)

**CONTROL BACTERIAL ECOSYSTEMS EVERYWHERE
(ESPECIALLY IN AN ANIMAL'S DIGESTIVE TRACT)**

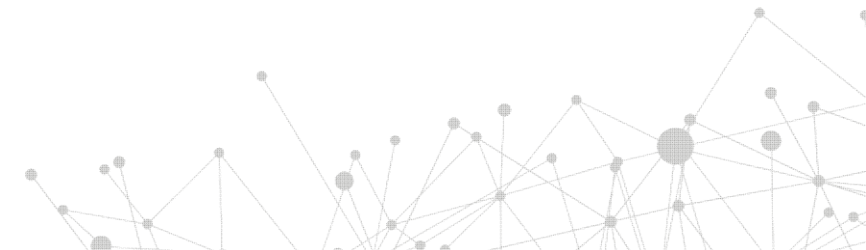




EARLY “BACTERIAL STABILITY” IS IMPORTANT IN AN ANIMAL’S DIGESTIVE TRACT



**BACTERIAL INFECTION RISK
“HIGH”
IMMUNE SYSTEM
“NOT FULLY DEVELOPED”**





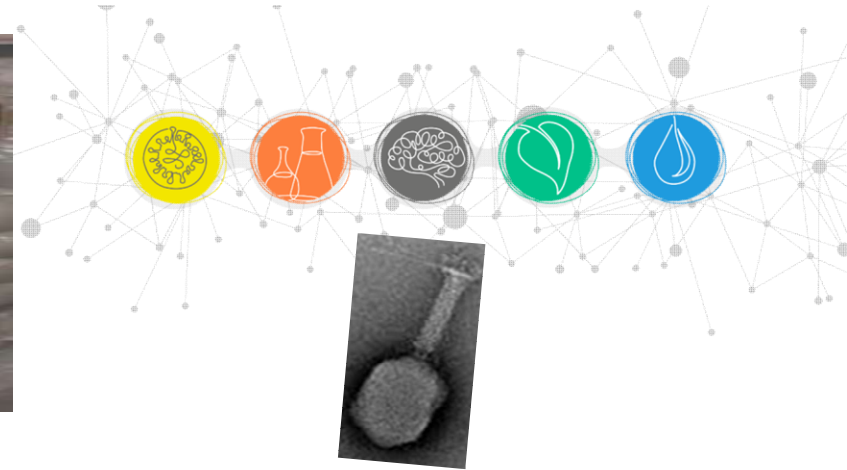
WHAT IS A MAJOR WAY THAT BACTERIOPHAGES PROTECT THE ANIMAL'S DIGESTIVE TRACT



**PATHOGENS ENTER THROUGH MUCOSAL SURFACES
MUCUS MAINTAINS A HIGH PHAGE TO BACTERIA
RATIO WHICH PROTECTS THE UNDERLYING EPITHELIUM
AND PREVENTS INFECTION**

**THE BACTERIOPHAGE BINDS TO THE MUCIN GLYCOPROTEINS
AND ATTACHMENT TO THE MUCIN RESULTS WHICH
PROVIDES A "NON-HOST DERIVED IMMUNITY"
BY DECREASING BACTERIAL NUMBERS**

QUESTION



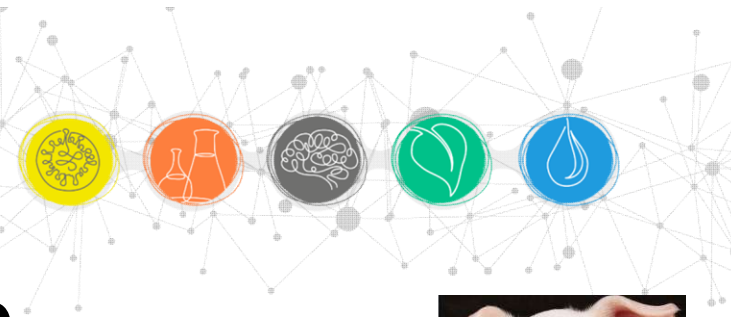
BACTERIOPHAGES ASSOCIATE TIGHTLY WITH MUCIN “VELCRO EFFECT”



BACTERIOPHAGES

...PROMOTE...

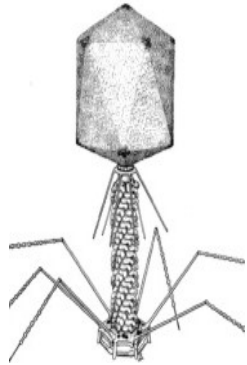
HEALTH OF THE DIGESTIVE TRACT AND
A STABLE MICROBIAL POPULATION



“PHAGEBIOTIC”



DO BACTERIOPHAGES ENTER THE BODY
OF THE ANIMAL FROM THE LUMEN OF
THE INTESTINAL TRACT?



...YES...

THEY ENTER THE BLOODSTREAM FROM
THE INTESTINE AND OTHER REGIONS OF
THE BODY AND TRANSPORTED ALL OVER
THE BODY TO VARIOUS ORGANS AND TISSUES

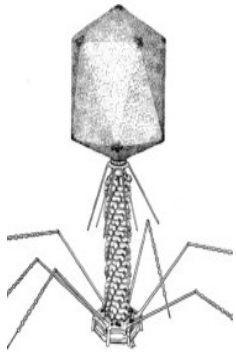
...THIS IS KNOWN AS...

“PHYSIOLOGICAL VIREMIA”
AND
“VIRAL TRANSLOCATION”

QUESTION



WHEN ONE BACTERIOPHAGE INJECTS ITS DNA INTO A BACTERIAL CELL AND CELL LYSIS OCCURS HOW MANY NEW BACTERIOPHAGES CAN BE FORMED ONCE "BURST SIZE" IS REACHED ?



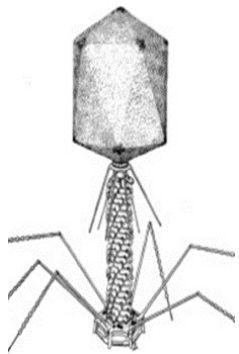
**THE NUMBER CAN VARY
BUT FROM 50-100(200) IS COMMON**



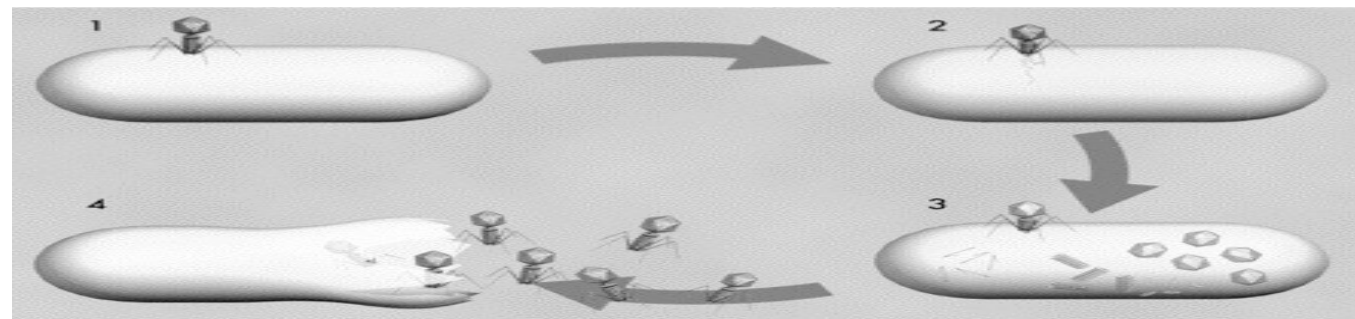
BACTERIAL CELL LYSIS

QUESTION

WHAT LIMITS THE NUMBER OF NEW
BACTERIOPHAGES ? WHY NOT MORE,
LET'S SAY 300, 500, 1000, 5,000 +

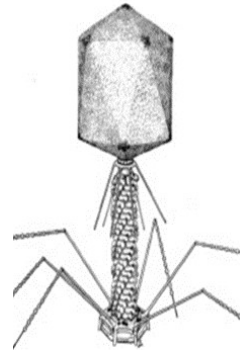


**BACTERIOPHAGE DNA COMMANDS
THE BACTERIAL CELL'S METABOLIC
MACHINERY TO PRODUCE
BACTERIOPHAGES AND EVENTUALLY
THE "BUILDING MATERIAL" WITHIN THE
BACTERIA REQUIRED FOR CONSTRUCTING
BACTERIOPHAGES IS DEPLETED**

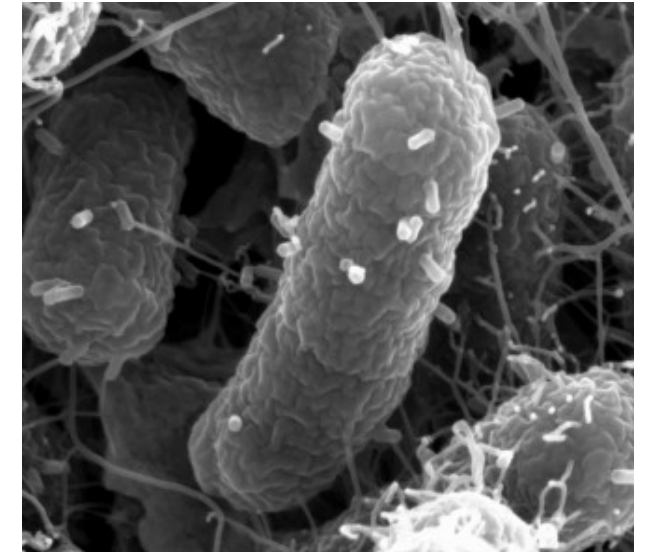
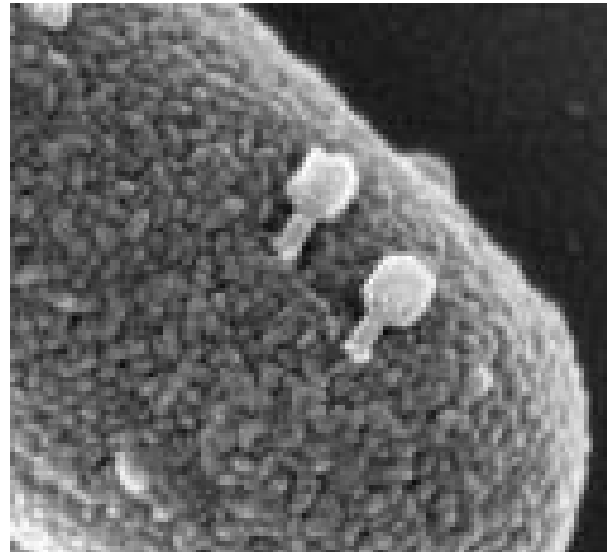


QUESTION

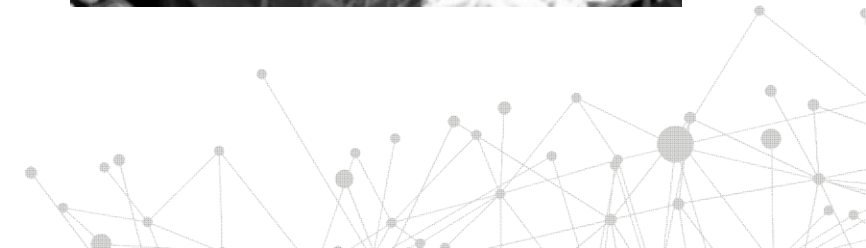
**IN COMPARISON TO BACTERIA
HOW BIG ARE BACTERIOPHAGES ?**



**BACTERIOPHAGES ARE NORMALLY
ABOUT 100 TIMES SMALLER
THAN BACTERIA**



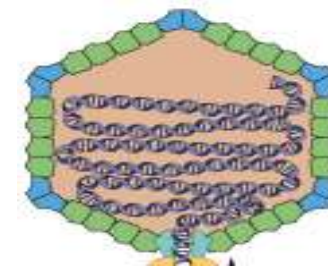
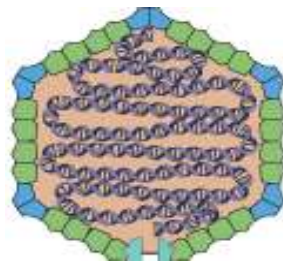
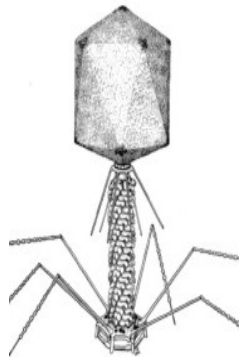
QUESTION



WHAT HAPPENS TO THE BACTERIOPHAGE
IN THE ENVIRONMENT AFTER ITS DNA
HAS BEEN INJECTED INTO THE BACTERIA ?

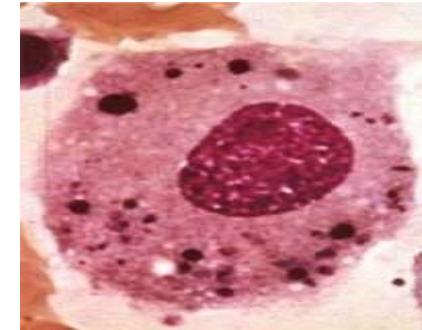
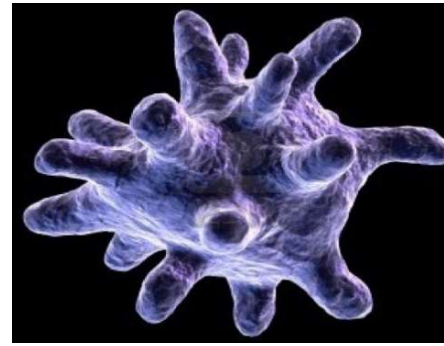
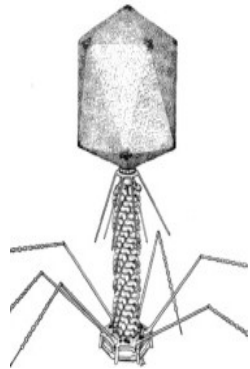
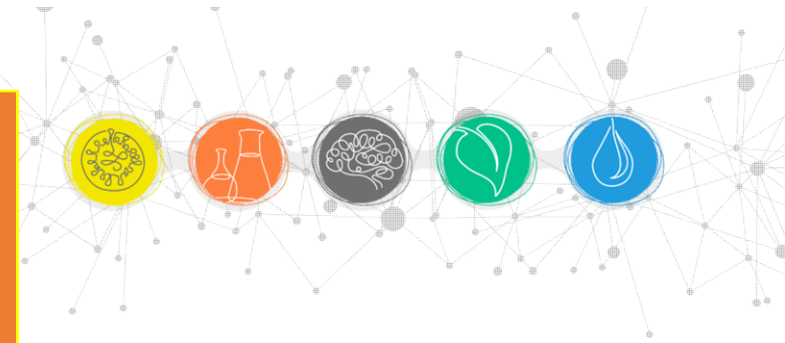


THE BACTERIOPHAGE IS THEN
NOTHING BUT AN EMPTY PROTEIN SHELL
WHICH WILL EVENTUALLY DECAY



QUESTION

WHAT HAPPENS TO THE BACTERIOPHAGE
IN THE ANIMAL AFTER ITS DNA
HAS BEEN INJECTED INTO THE BACTERIA ?



RETICULOENDOTHELIAL SYSTEM
“MACROPHAGE SYSTEM”

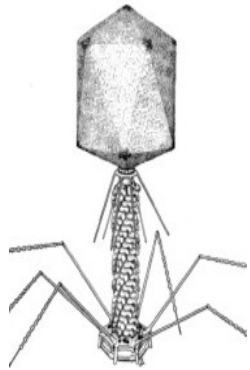
IN THE ANIMAL

THE MACROPHAGES
CONSUME THE EMPTY SHELL
OF THE BACTERIOPHAGES

QUESTION



**DO BACTERIOPHAGE RESISTANT
BACTERIA EVER DEVELOP ?**



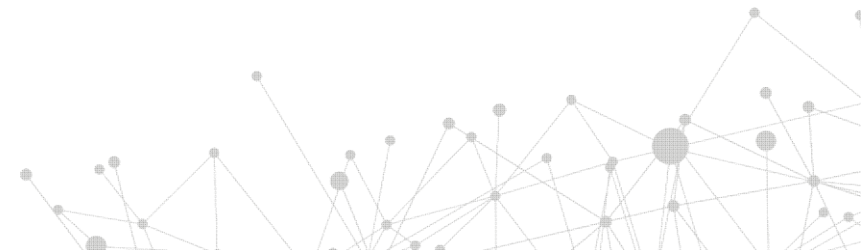
YES

...HOWEVER...

**THE RESISTANT BACTERIA ARE A MINORITY
AND THE BACTERIOPHAGES ARE CONSTANTLY
CO-EVOLVING AND WILL EVENTUALLY
DESTROY THE BACTERIA**

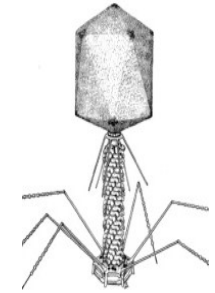
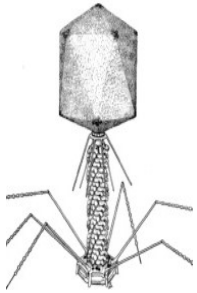
**3.5 BILLION YEARS WITHOUT ANY
TOTAL RESISTANCE DEVELOPING**

QUESTION



...IMPORTANT NOTE...

**DEVELOPING RESISTANCE
TO BACTERIOPHAGES
IS NOT WITHOUT CONSEQUENCES
AND IS COSTLY TO THE BACTERIA**









...BACTERIA EXHIBIT...

- 1) **LESS VIRULENCE TO HOST**
- 2) **LOWER REPLICATION RATE**
- 3) **DECREASED LIFE SPAN**
- 4) **INCREASED SENSITIVITY TO ANTIBIOTICS**
- 5) **INABILITY TO ATTACH TO AND INVADE HOST CELLS**

GROWTH PROMOTING ANTIBIOTICS



“EXPECTED PERFORMANCE RESPONSES”

		<u>IMPROVEMENT</u>	
		<u>WEIGHT GAIN (%)</u>	<u>FCR (%)</u>
BROILER		+ 3.6	- 3.4
LAYING HEN		+ 2.8	- 2.7
TURKEY		+ 3.1	- 2.2
PIG	STARTING 	+ 15.7	- 8.6
	GROWING 	+ 8.1	- 4.8
	FINISHING 	+ 3.2	- 2.0

SOURCE: Rosen, 1995, QUOTED BY Schwarz in Kraftfutter 9/97 pp.349





MAJOR FACTORS KNOWN TO INFLUENCE THE MAGNITUDE OF RESPONSE TO GROWTH PROMOTING ANTIBIOTICS IN VARIOUS SPECIES OF ANIMALS

FACTOR



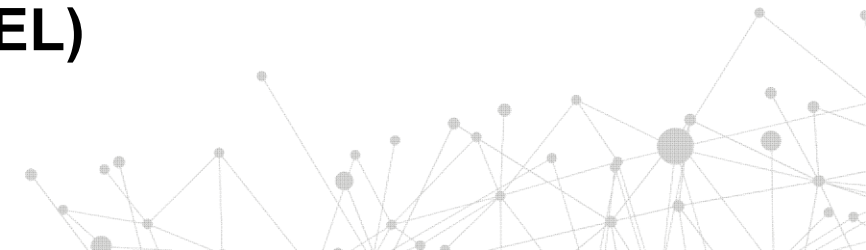
GERM FREE ENVIRONMENT (NO MICROBES)

FARM HYGIENE (CLEAN VS DIRTY)

AGE OF ANIMAL (YOUNG VS OLD)



FARM MANAGEMENT (STRESS LEVEL)



MAJOR FACTOR

GERM FREE ENVIRONMENT (NO MICROBES)

FARM HYGIENE (CLEAN VS DIRTY)

AGE OF ANIMAL (YOUNG VS OLD)

FARM MANAGEMENT (STRESS LEVEL)

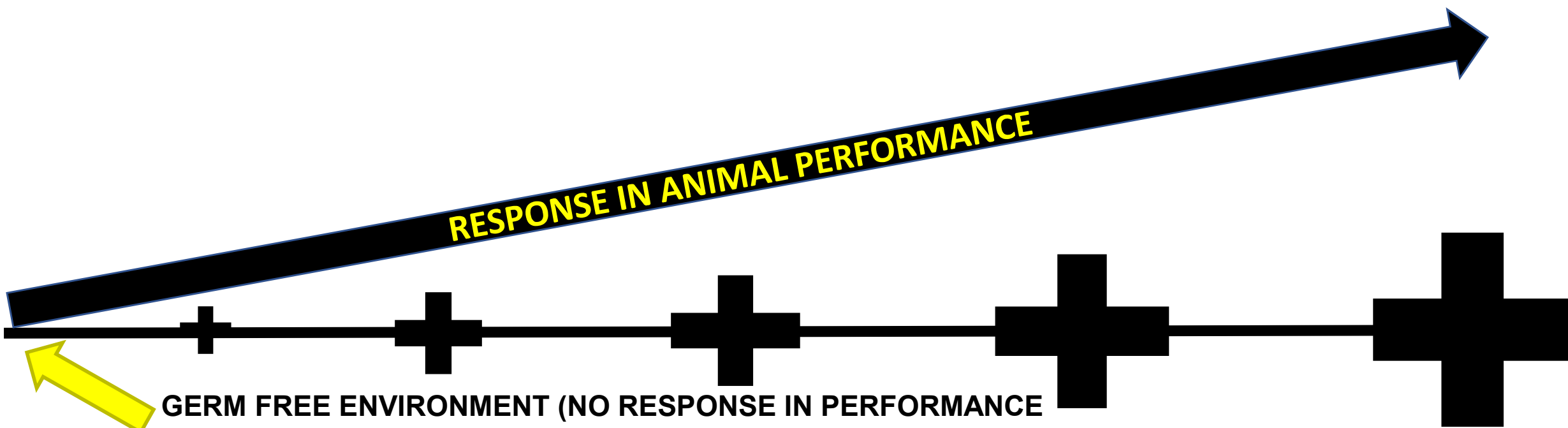


RESPONSE IN ANIMAL PERFORMANCE

MAJOR FACTOR



GERM FREE ENVIRONMENT (NO MICROBES)



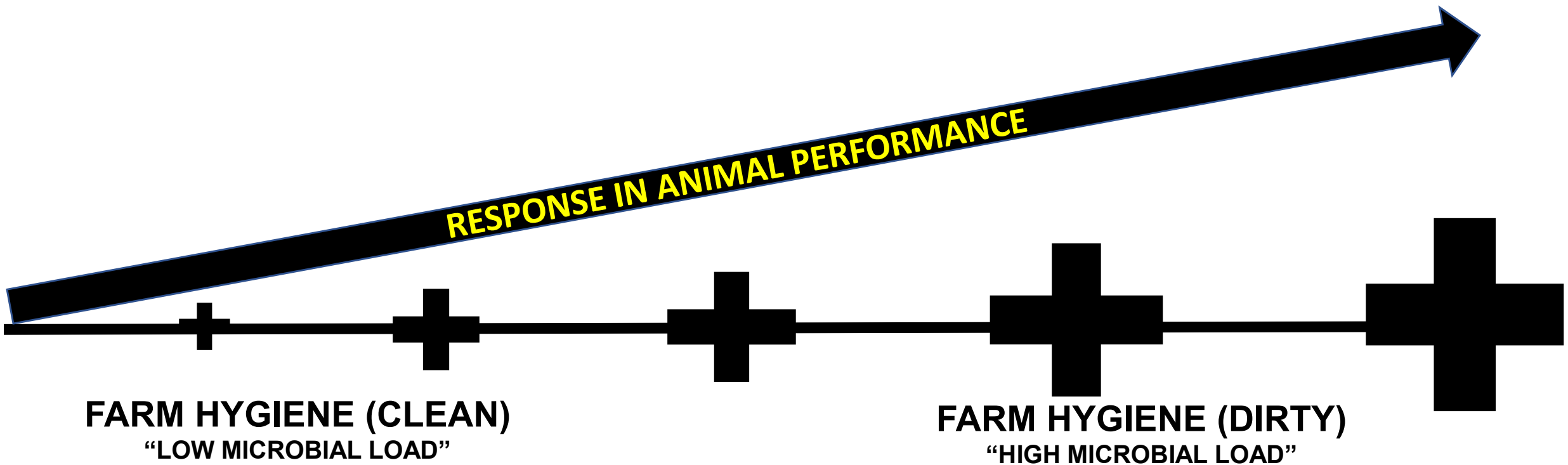
GERM FREE ENVIRONMENT (NO RESPONSE IN PERFORMANCE IS EXPECTED WHEN USING GROWTH PROMOTING ANTIBIOTICS)

THIS IS ALSO TRUE WHEN USING BACTERIOPHAGES

MAJOR FACTOR



FARM HYGIENE (CLEAN VS DIRTY)

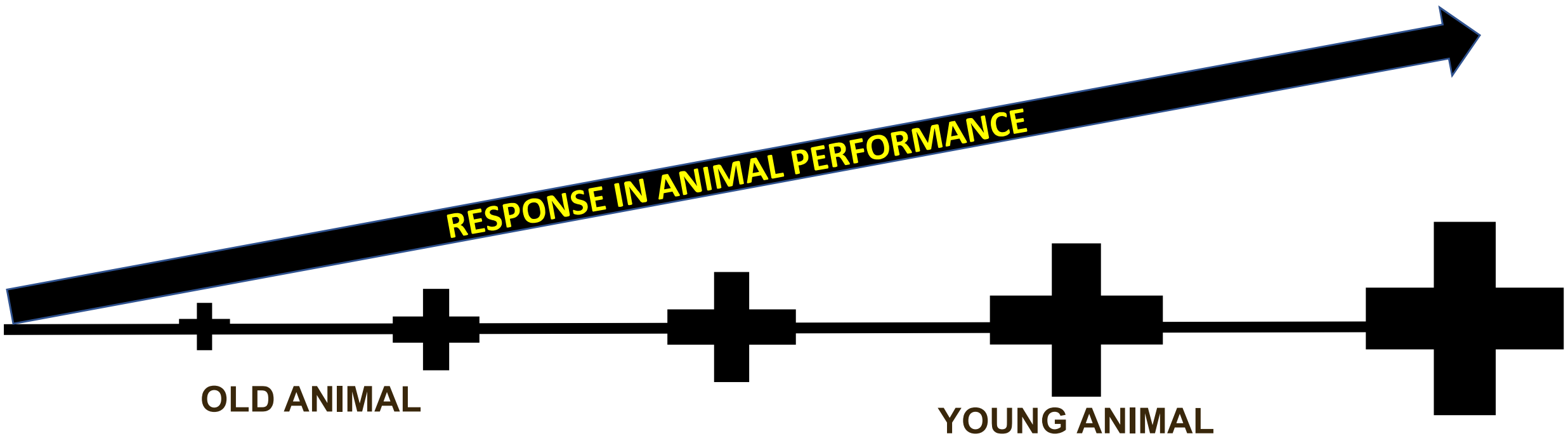


THIS IS ALSO TRUE WHEN USING BACTERIOPHAGES

MAJOR FACTOR



AGE OF ANIMAL (YOUNG VS OLD)

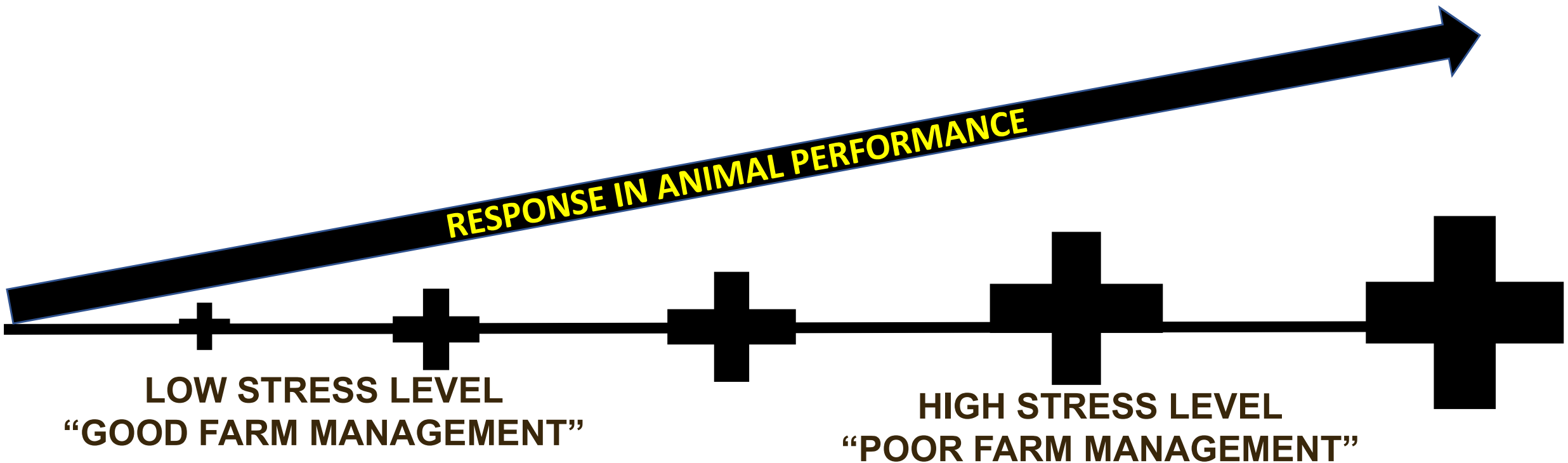


THIS IS ALSO TRUE WHEN USING BACTERIOPHAGES

MAJOR FACTOR



FARM MANAGEMENT (STRESS LEVEL)



THIS IS ALSO TRUE WHEN USING BACTERIOPHAGES

ANTIBIOTICS

"CURRENT POSITION"



**CONSUMER DEMAND
HAS ALWAYS BEEN THE MAJOR DRIVING
FORCE IN THE ANIMAL MEAT INDUSTRY**

...AND NOW...

**CONSUMERS ARE DEMANDING
ALL ANIMAL PRODUCTS BE PRODUCED
WITHOUT THE USE OF ANTIBIOTICS**

EUROPEAN UNION: 1/1/2006



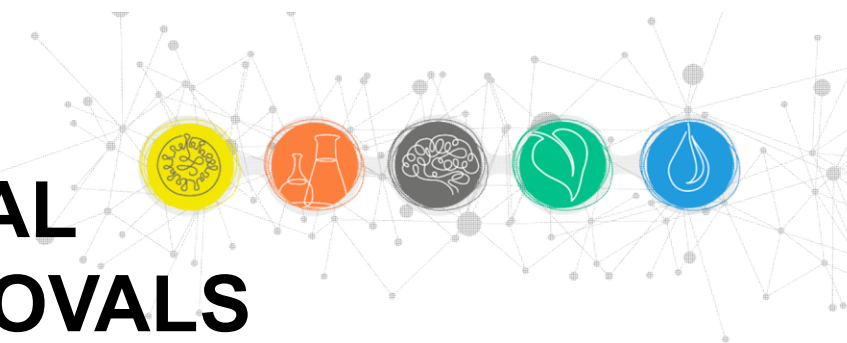
ANTIBIOTICS



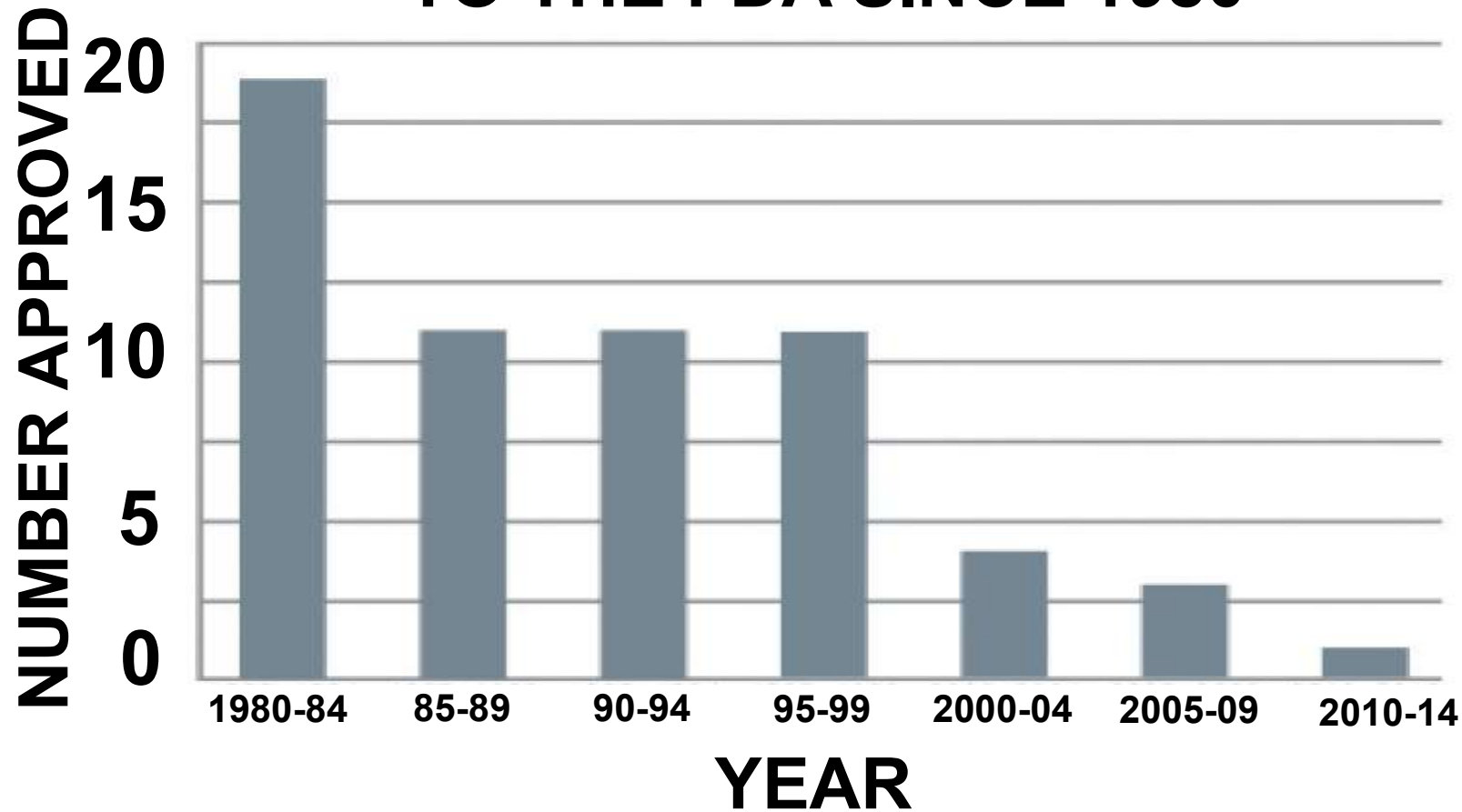
...FACT...

**IT IS VERY UNLIKELY THAT ANY NEW GROWTH PROMOTING
ANTIBIOTICS WILL BE DEVELOPED AND APPROVED
IN THE NEAR FUTURE FOR USE IN THE ANIMAL INDUSTRY**

**THE COST OF DEVELOPMENT AND TESTING ANTIBIOTICS
IS BECOMING COST PROHIBITIVE
AND
THE FUTURE TREND SEEMS TO BE NOT TO APPROVE
AS MANY NEW ANTIBIOTICS AS IN THE PAST**



“SYSTEMIC” ANTIBACTERIAL NEW DRUG APPLICATION APPROVALS TO THE FDA SINCE 1980



SOURCE: THE FOOD AND DRUG ADMINISTRATION AND CENTER FOR DRUG EVALUATION AND RESEARCH

POSSIBLE ALTERNATIVE REPLACEMENTS FOR GROWTH PROMOTING ANTIBIOTICS



**ANTIBACTERIAL
VACCINES**

**MICROBIAL
COMMUNICATION
DISRUPTORS**

**HOST IMMUNE
STIMULATORS**

**PROBIOTICS
PREBIOTICS
SYNBIOTICS**

BACTERIOPHAGES

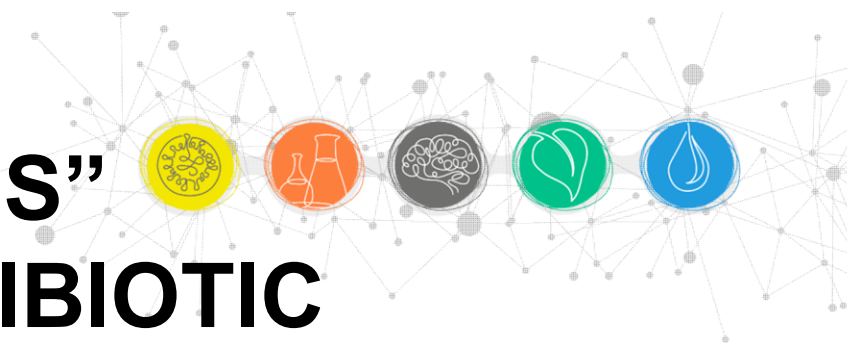
**PLANT EXTRACTS
PLANT OILS
MICROBIAL BINDERS**

**ANTIMICROBIAL
PEPTIDES**

**NUMEROUS
OTHERS**

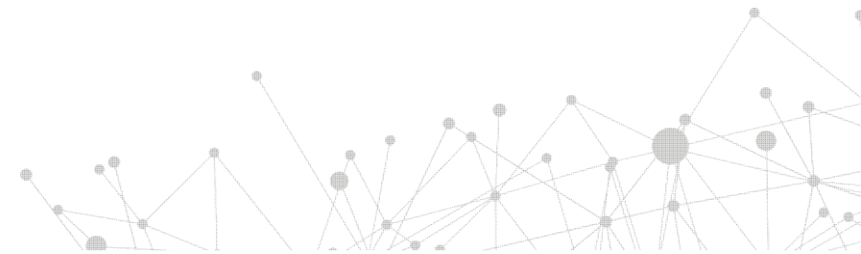
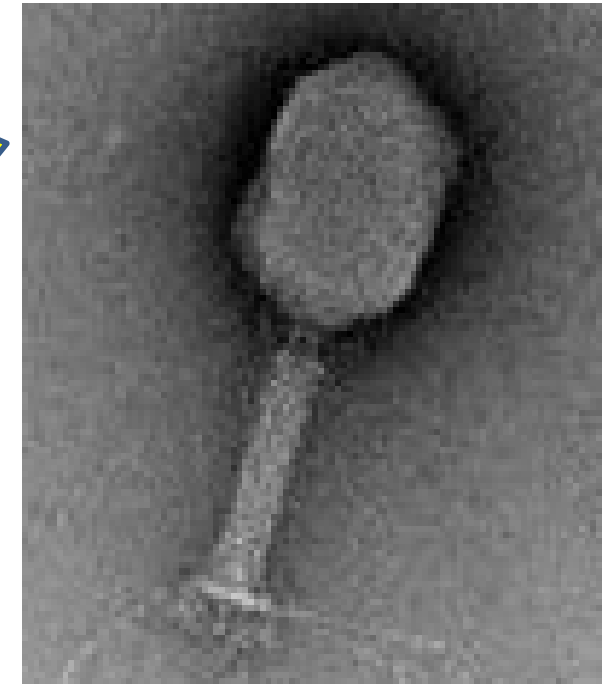
**FEED ENZYMES
ORGANIC ACIDS**

“IDEAL CHARACTERISTICS” OF GROWTH PROMOTING ANTIBIOTIC ALTERNATIVES

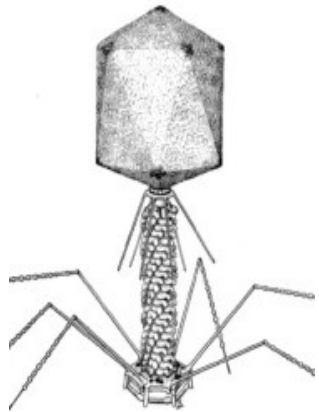


- 1) NON-TOXIC AND HAVE NO SIDE EFFECTS
- 2) EASY TO ELIMINATE FROM THE SYSTEM
- 3) NO ENVIRONMENTAL RESIDUES
- 4) NO BACTERIAL RESISTANCE
- 5) STABLE
- 6) STABLE
- 7) DO NOT
- 8) WORK IN THE GUT AND INTESTINE
- 9) AFFECT BACTERIA
- 10) ENHANCE RESISTANCE TO DISEASE
- 11) PROMOTE GROWTH AND IMPROVE FEED EFFICIENCY
- 12) *PROVIDE A POSITIVE CONSISTENT PERFORMANCE RESPONSE*

BACTERIOPHAGES
 POSSESS ALL OF THESE
 “IDEAL CHARACTERISTICS”



**CAN BACTERIOPHAGES BE
USED WITH ANTIBIOTICS ?**



YES... VERY SUCCESSFULLY

ANTIBIOTICS

**ARE NOT SPECIFIC FOR A CERTAIN BACTERIAL SPECIES
AND EVEN LESS SPECIFIC AGAINST CERTAIN STRAINS
OF BACTERIA WITHIN A SPECIES**

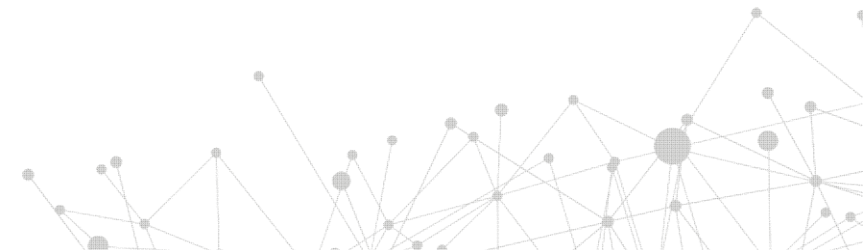
(USUALLY KILL BACTERIA UNDERGOING A RAPID GROWTH PHASE)

BACTERIOPHAGES

**ARE VERY SPECIFIC FOR ONLY ONE BACTERIAL SPECIES
AND SPECIFIC FOR CERTAIN STRAINS WITHIN A SPECIES**

(KILL BACTERIA INDEPENDENTLY OF THE GROWTH PHASE)

QUESTION



HOW SAFE ARE BACTERIOPHAGES

????

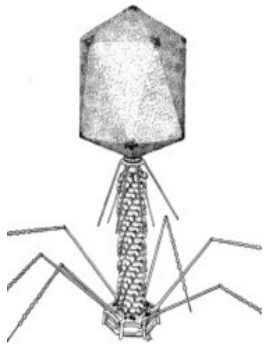
VERY SAFE

APPROVED BY

USDA, FDA & FSIS

FOR USE ON MANY FOOD ITEMS

(SUCH AS CARCASSES AND READY TO EAT MEAT PRODUCTS)



QUESTION



...BACTERIOPHAGES...

FAVORABLE EXPECTED CONSEQUENCES OF THEIR USE IN ANIMAL DIETS

- GROWTH ENHANCEMENT
- IMPROVED FEED CONVERSION
- IMPROVED FLOCK/HERD UNIFORMITY
- LESS SUBCLINICAL DISEASE
- BETTER INTESTINAL “BACTERIAL STABILITY”
(PREVENT DYSBACTERIOSIS)
- REDUCED IMMUNE STIMULATION
- IMPROVED PRODUCT SAFETY & QUALITY

...AND...

OTHERS



...ANTIBIOTICS...



**THIS HEADLINE SUMS UP EVERYTHING
ABOUT THE FUTURE USE OF
ANTIBIOTICS USED FOR GROWTH PROMOTION**

ScienceNews
MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC

Science & the Public

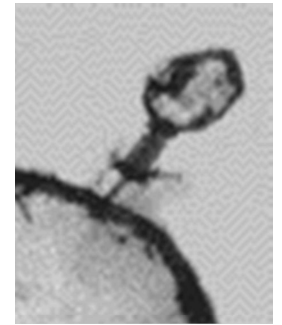
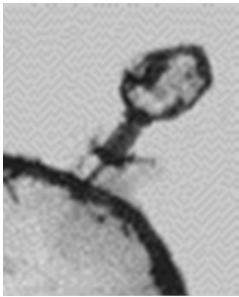
Humans & Society, Nutrition, Earth & Environment, Biomedicine, Agriculture

Growth-promoting antibiotics: On the way out?

Court instructs FDA to resume efforts aimed at banning use of low-dose antibiotics in livestock feed

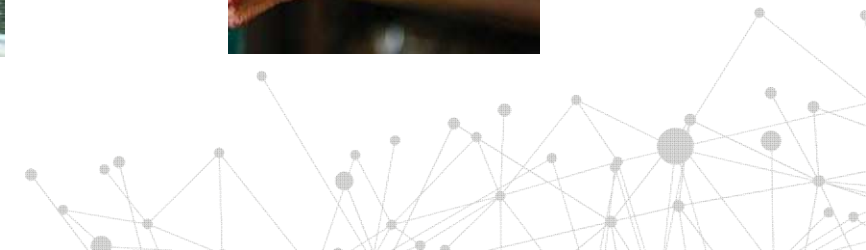
By Janet Raloff 1:30pm, March 23, 2012

BACTERIOPHAGES



...FACT...

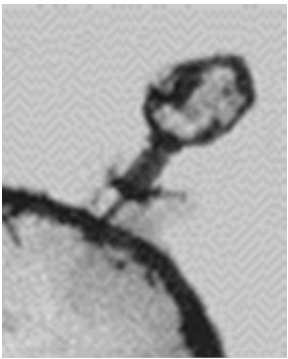
...IN THE PAST AND PRESENTLY...
MOST BACTERIOPHAGE RESEARCH
IS RELATED TO HUMANS
“PHAGE THERAPY”



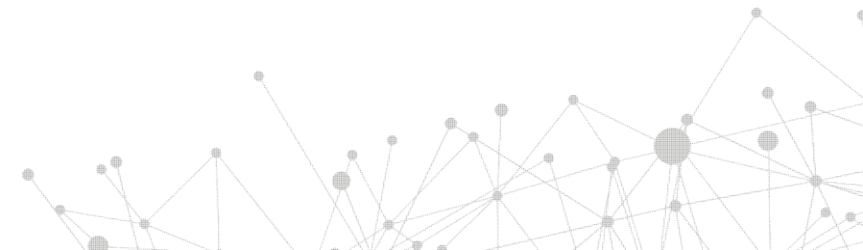
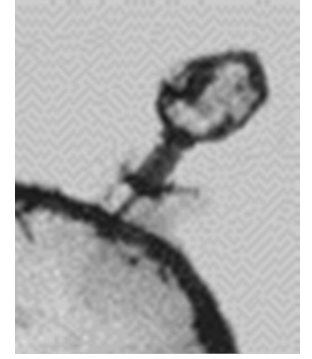
BACTERIOPHAGES



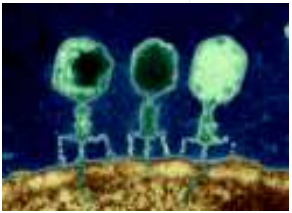
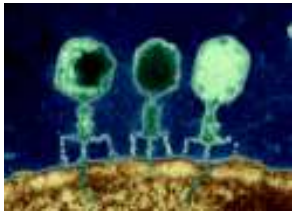
...FACT...



**RECENT RESEARCH INTEREST IN THE USE
OF BACTERIOPHAGES IN ANIMAL DIETS IS
INCREASING AT A VERY RAPID RATE
AND
INTEREST WILL CONTINUE TO INCREASE AS WE
DISCOVER MORE ABOUT THERE BENEFITS
IN PROMOTING ANIMAL PERFORMANCE**



BACTERIOPHAGES



PUBLISHED RESEARCH



Effects of Dietary Supplementation of Bacteriophage on Productive Performance and Egg Quality in Laying Hens after Forced-molting
 G. P. Han, J. E. Shin, J. H. Kim, and D. Y. Kil
 Department of Animal Science and Technology, Chung-Ang University, Anseong-si, Republic of Korea

British Poultry Science
 Publication details, including instructions for authors and subscription information:
<http://www.tandfonline.com/loi/1362>
Effect of dietary supplementation of bacteriophage on productive performance, egg quality and caecal bacterial composition in laying hens
 G.-B. Kim* & D.Y. Kil*
 Chung-Ang University, Anseong-si, Chungcheongnam-do, 330-714, Korea
 Published online: 13 Jan 2015.

THE ASIAN-AUSTRALASIAN ASSOCIATION OF ANIMAL PRODUCTION SCIENTISTS
Effects of Bacteriophage Supplementation on Productive Performance, Egg Quality, and Caecal Bacterial Composition in Laying Hens
 Department of Animal Science and Technology, Chung-Ang University, Anseong-si, Chungcheongnam, 330-714, Korea

THE ASIAN-AUSTRALASIAN ASSOCIATION OF ANIMAL PRODUCTION SCIENTISTS
Evaluation of Bacteriophage Supplementation on Growth Performance, Blood Characteristics, Relative Organ Weight, Breast Muscle Characteristics and Excreta Microbial Shedding in Broilers
 J. P. Wang, L. Yan, J. H. Lee² and I. H. Kim*
 Department of Animal Resource and Science, Dankook University, Cheonan, Choongnam, 330-714, Korea

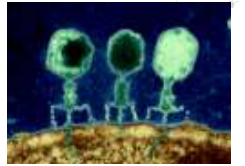
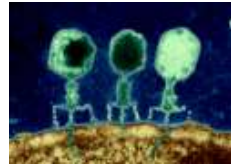


BACTERIOPHAGES

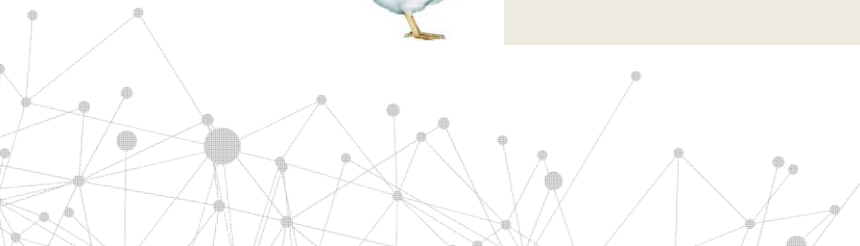


PUBLISHED RESEARCH

- Effect of dietary supplementation of bacteriophage on performance, egg quality and caecal bacterial populations in laying hens. *British Poultry Science*, 2015
- Effect of dietary supplementation of bacteriophage on performance and caecal bacterial populations in broiler chickens under different housing systems. *Livestock Science*, 2014
- Bacteriophage supplementation improves the growth performance of growing pigs but does not affect their health. *Journal of Animal Science*, 2014
- Evaluation of bacteriophage supplementation on performance, blood characteristics and caecal microflora in laying hens. *AJAS*, 2013
- Effect of bacteriophage supplementation on growth performance, nutrient digestibility, blood characteristics and caecal microbial shedding in growing pigs. *AJAS*, 2012
- Effectiveness of bacteriophage supplementation on egg performance, egg quality, excreta microflora, and moisture content in laying hens. *AJAS*, 2012



**SUCCESS
STORIES**

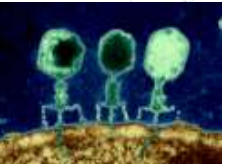
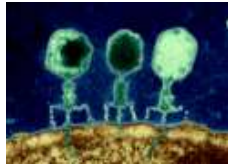


BACTERIOPHAGES



PUBLISHED RESEARCH

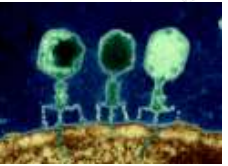
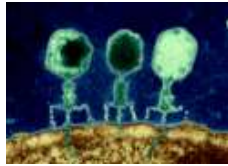
- Bacteriophage based nature friendly control technology for prevention and treatment of bacterial infection commonly encountered in flounder *Paralichthys olivaceus* culture. 5th Int. Symposium on Aquaculture. Asia, 2015
- Protective effect of bacteriophage against *Salmonella* infection on weaning pigs. 6th Asia Pacific Conference on Bacteriophage, 2013
- Protective effect of bacteriophage against enterotoxigenic *E. coli* K88 infection on weaned pigs. 6th Asia Pacific Conference on Bacteriophage, 2013
- Effect of dietary supplementation of bacteriophage on laying performance, egg quality, and cecal microbial population in laying hens. WCAP, 2013



BACTERIOPHAGES



PUBLISHED RESEARCH



Occurrence of *Salmonella*-Specific Bacteriophages in Swine Feces Collected from Commercial Farms

Todd R. Callaway,¹ Tom S. Edrington,¹ Andrew Brabban,² Elizabeth Kutter,² Locke Karriker,³ Chad Stahl,⁴ Elizabeth Wagstrom,⁵ Robin C. Anderson,¹ Ken Genovese,¹ Jack McReynolds,¹ Roger Harvey,¹ and David J. Nisbet¹

The impact of orally administered phages on host immune response and microbial communities

Yingying Hong, ..., Ketaki Bhide, Kyle Schmidt

Bacteriophage-mediated control of the mammalian microbiome

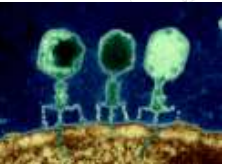
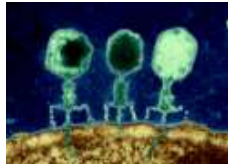
Breck A. Duerksen, ..., ppat.1007310

The Efficacy of Isolated Bacteriophages from Pig Farms against ESBL/AmpC-Producing *Escherichia coli* from Pig and Turkey Farms

BACTERIOPHAGES



PUBLISHED RESEARCH



Phage Therapy To Reduce Preprocessing *Salmonella* Infections in Market-Weight Swine

Samantha K. Wall, Jiayi Zhang, Marcos H. Rostagno, Paul D. Ebner

The newly isolated lytic bacteriophage *Phi* and st104b are highly virulent against *Salmonella enteritidis*

O'Flynn G¹, Collins

Evaluation of bacteriophage cocktails against *Salmonella* in weaned pigs

Byoung-Joo SEO,¹ Sung-Hyun MOON,¹ Won-II KIM^{1,*}, Chang-Gi JEONG,¹ Hyeon-Gi LEE,¹ Byeong Yeal JUNG,^{2,*} and

Bacteriophages as antimicrobial agents against major pathogens in swine: a review

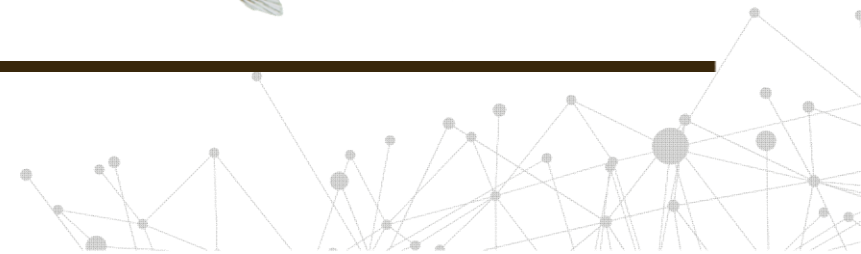
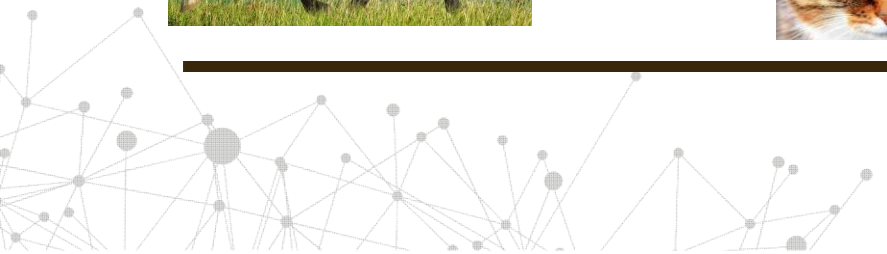
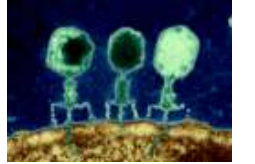
Jiancheng Zhang, Zhen Li, Zhenhui Cao, Lili Wang, Xiaoyu Li, Shuying Li, and Yongping Xu[✉]

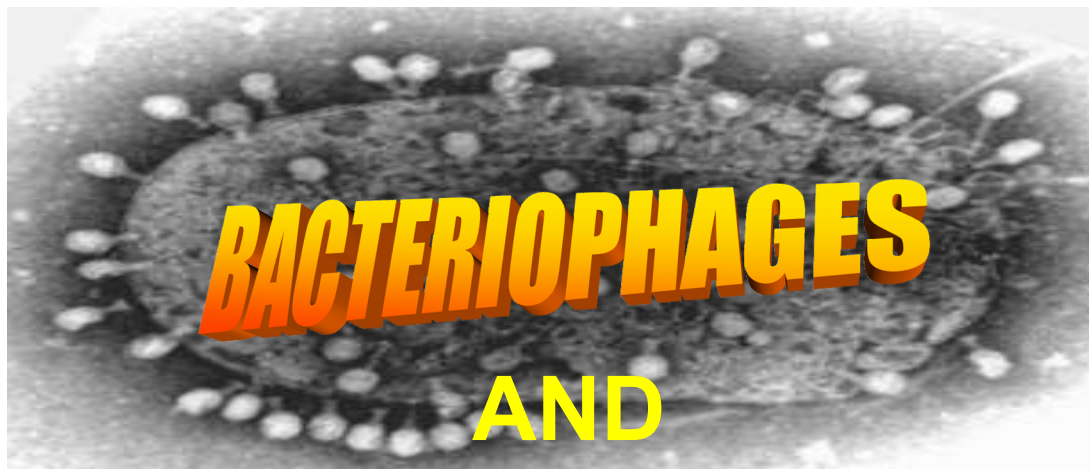
SUCCESS STORIES

BACTERIOPHAGES



PUBLISHED RESEARCH





...FINALLY...

**HOW DO I FEEL ABOUT THE FUTURE
WITHOUT ANTIBIOTICS**



