What's Hot In Medical Microbiology

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royalty - \$1 /book for Bugs and Drugs



Objectives:

Microbiology news on antimicrobial resistance Microbiology news that might improve antimicrobial stewardship Microbiology news on rapid detection of antimicrobial resistance Microbiology news that might make you an interesting dinner guest



Antibiotic Resistance Threats in the United States CDC 2013

• Healthcare implications

- 2 million people infected
 - 23,000 deaths
- \$20 billion direct healthcare costs
- \$35 billion- additional cost

Prioritization of bacteria into 3 categories of threat

Urgent / Serious / Concerning

Urgent:

- C. difficile
- Carbapenem-resistant Enterobacteriaceae (CRE)
- Drug resistant *Neisseria gonorrhoeae*





Emergence and global spread of epidemic healthcare-associated *Clostridium difficile*

Miao He, Fabio Miyajima, Paul Roberts, Louise Ellison, Derek J Pickard, Melissa J Martin, Thomas R Connor, Simon R Harris, Derek Fairley, Kathleen B Bamford, Stephanie D'Arc, Jon Brazier, Derek Brown, John E Coia, Gill Douce, Dale Gerding, Hee Jung Kim, Tse Hsien Koh, Haru Kato, Mitsutoshi Senoh, Tom Louie, Stephen Michell, Emma Butt, Sharon J Peacock, Nick M Brown 🗈 et al.

Nature Genetics 45, 109-113 (2013)

- 2 distinct epidemic lineages (FQR1/FQR2) emerged in North America over a short period
- acquired same FQ resistance mutation and highly related conjugative transposon
 - not due to genetic changes in *tcd*C gene of the PaLoc
- FQR2 spread more widely in healthcare settings in UK, continental Europe and Australia



ORIGINAL ARTICLE

Increased moxifloxacin utilization associated with an unrestricted addition to a drug reimbursement formulary: A population-based analysis

Alissa Jade Wright MD FRCPC¹, Fawziah Marra PharmD^{1,2}, Mei Chong MSc³, Catharine Chambers MSc³, William R Bowie MD FRCPC¹, David M Patrick MD FRCPC MHSc^{3,4}

Can J Infect Dis Med Microbiol Vol 25 No 1 January/February 2014

Health Canada approval - 2000 British Columbia formulary - 2009

2001-2010: 7-fold increase in moxifloxacin utilization

- 2.1% increase every month after 2009
- 29% linked to guideline concordant diagnostic code (ABS/AECB/CAP)
- 53.5 % no other antibiotic in previous 90 days
- if antibiotic in previous 90 days- 41.5% received a quinolone





Plasmid-Mediated Quinolone Resistance Genes in Enterobacteriaceae from American Crows: High Prevalence of Bacteria with Variable gnrB Genes

Dana Halová, Ivo Papoušek, Ivana Jamborova, Martina Masarikova, Alois Cizek, Nicol Janecko, Veronika Oravcova, Ludek Zurek, Anne B. Clark, Andrea Townsend, Julie C. Ellis, and Ivan Literak

Antimicrob. Agents Chemother. February 2014 58:2 1257-1258; published ahead of print 18 November 2013, doi:10.1128/AAC.01849-13

Wild birds should not be exposed to antimicrobial agents

590 samples of fresh crow feces

- ▶ 62% quinolone resistant Enterobacteriaceae
- 33% plasmid mediated quinolone resistance

?? extent of environmental contamination



Does Doxycycline Protect Against Development of *Clostridium difficile* Infection?

Sarah B. Doernberg,¹ Lisa G. Winston,¹ Daniel H. Deck,² and Henry F. Chambers¹

¹Department of Internal Medicine, Division of Infectious Diseases, University of California, San Francisco, and ²Department of Pharmaceutical Sciences, San Francisco General Hospital, California

Clin Infect Dis. 2012 Sep;55(5):615-20.

2,305 patients admitted with community infections

- treated with ceftriaxone
- 39% also received doxycyline

Rate of CDI:

- 8.11 per 10,000 ceftriaxone alone
- 1.67 per 10,000 ceftriaxone + doxycycline

Explanation:

- activity against anaerobes including C. difficile
- protein synthesis inhibitor- attenuates toxin production
- maximal absorption in upper GI tract-minimal effect on gut flora



Clinical Infectious Diseases

Multiple Broad-Spectrum Beta-Lactamase Targets Importance

Kathy A. Mangold^{a,b}, Barbara L. Voss^a, Kamaljit Singh^c, Richard B. Thomson Jr.^{a,b}, Donna M. Schora^a, Lance R. Peterson^{a,b} and Karen L. Kaul^{a,b}

JCM 2013 (October)

previous CDC study - MMWR 2013:

- 2/3 of residents from 2 Chicago nursing homes:
 - KPC carbapenemase colonization

Point prevalence study in 2 LTC facilities, Chicago

• Real time PCR for $b|a_{KPC}$, $b|a_{NDM}$, $b|a_{VIM}$, $b|a_{IMP}$, $b|a_{CTX-M}$

Results:

- 67.6% KPC carbapenemase
- + 73.5% 30 CTX-M (25 also KPC +) / 4 VIM / 2 VIM + KPC





Clinical Microbiology Reviews Trends in Human Fecal Carriage of Extended-Spectrum β-Lactamases in the Community: Toward the Globalization of CTX-M

Paul-Louis Woerther, Charles Burdet, Elisabeth Chachaty and Antoine Andremont *Clin. Microbiol. Rev.* 2013, 26(4):744. DOI: 10.1128/CMR.00023-13.

WHO Estimate of ESBL carriers (2010)

- South East Asia- 1.1 billion
- Western Pacific 280 million
- Eastern Mediterranean- 180 million
- Africa- 110 million
- Americas 48 million
- Europe– 35 million

ESBL- fecal-oral dissemination:

- poor access to drinking water
- poverty
- high population density



Molecular Diagnostics for Gonorrhoea: Implications for Antimicrobial Resistance and the Threat of Untreatable Gonorrhoea

Nicola Low 🙆, Magnus Unemo, Jørgen Skov Jensen, Judith Breuer, Judith M. Stephenson

Published: February 04, 2014 • DOI: 10.1371/journal.pmed.1001598



National surveillance of methicillin-resistant Staphylococcus aureus in China highlights a still-evolving epidemiology with 15 novel emerging multilocus sequence types.

Xiao M1, Wang H, Zhao Y, Mao LL, Brown M, Yu YS, O'Sullivan MV, Kong F, Xu YC.

J Clin Microbiol. 2013 Nov;51(11):3638-44. doi: 10.1128/JCM.01375-13. Epub 2013 Aug 28.

MRSA rates:50-70% of isolates

Study:

>1,000 HA-MRSA in 6 month period - 69 hospitals in 45 large cities

- 36 multi-locus sequence types
 - 15 novel emerging MLSTs
 - 1 novel type found in 3 hospitals in 2 large cities



Journal of Clinical Microbiology

Worrisome Trend of New Multiple Mechanisms of Linezolid Resistance in Staphylococcal Clones Diffused in Italy

Floriana Campanile,^a Gino Mongelli,^a Dafne Bongiorno,^a Chiara Adembri,^b Milva Ballardini,^c Marco Falcone,^d Francesco Menichetti,^e Antonella Repetto,^r Carla Sabia,^h Assunta Sartor,^g Claudio Scarparo,^g Carlo Tascini,^e Mario Venditti,^d Federica Zoppi,^b Stefania Stefani^a

> J Clin Microbiol. Apr 2013; 51(4): 1256–1259. doi: <u>10.1128/JCM.00098-13</u>

50 isolates of invasive linezolid R MRSA 2 years (2010-11)

- erythromycin R–89%
- lincomycin R–100%
- levofloxacin R-100%
- gentamicin R 75.5%
- TMP–SMX R 55.5%
- vancomycin MIC₉₀- 4 μg/mL

9 presumptive mechanisms of resistance

62% – previous linezolid therapy

Journal of Clinical Microbiology Journal of Clinical Microbiology Evaluation of Vancomycin Susceptibility Testing for Methicillin-Resistant Staphylococcus aureus: Comparison of Etest and Three Automated Testing Methods

Michael J. Rybak, Celine Vidaillac, Helio S. Sader, Paul R. Rhomberg, Hossein Salimnia, Lawrence E. Briski, Audrey Wanger and Ronald N. Jones *J. Clin. Microbiol.* 2013, 51(7):2077. DOI: 10.1128/JCM.00448-13. Published Ahead of Print 17 April 2013.

Comparison of MicroScan, Vitek2, Phoenix, E test to microbroth dilution(MBD) Absolute agreement:

- Phoenix 66.2%
- Vitek 2 –54.3%
- MicroScan (prompt method) 74.1%
- MicroScan (turbidity method) 61.8%
- E test 36.7% values 1-2 dilutions higher

Tendency to under call MIC of 2µg /mL:

- Phoenix 76%
- Vitek 2 20%



mecC S. aureus

- divergent *mec*A homologue within novel SCCmec XI element
- CoNS potential origin / animal to human transmission
- produces negative PBP2' and PCR assay (*mec*A)
- Reported throughout western Europe (0.5% of phenotypic MRSA)

Use of Vitek 2 Antimicrobial Susceptibility Profile To Identify *mecC* in Methicillin-Resistant Staphylococcus aureus

Edward J. P. Cartwright, Gavin K. Paterson, Kathy E. Raven, Ewan M. Harrison, Theodore Gouliouris, Angela Kearns, Bruno Pichon, Giles Edwards, Robert L. Skov, Anders R. Larsen, Mark A. Holmes, Julian Parkhill, Sharon J. Peacock and M. Estée Török J. Clin. Microbiol. 2013, 51(8):2732. DOI: 10.1128/JCM.00847-13.

if clox S/cefoxitin R (Vitek):

sensitivity 88.7% / specificity 99.5% for identifying mecC

- PPV 47% (*mec*C)
- NPV if non clox S/R result 99.9% (not *mec*C)

Vitek 2 overrides S/R result to call MRSA- might miss emergence of mecC



Cefazolin high-inoculum effect in methicillinsusceptible *Staphylococcus aureus* from South American hospitals

Sandra Rincón¹, Jinnethe Reyes^{1,2}, Lina Paola Carvajal¹, Natalia Rojas¹, Fabián Cortés³, Diana Panesso^{1,2}, Manuel Guzmán⁴, Jeannete Zurita^{5,6}, Javier A. Adachi⁷, Barbara E. Murray^{2,8}, Esteban C. Nannini⁹ and Cesar A. Arias^{1,2,*}

JAC 2013; 68: 2773-2778

MSSA

isolates: 296 bloodstream/68 osteomyelitis infections

cefazolin MICs using standard inoculum 10⁵cfu/mL vs high inoculum10⁷ cfu/mL

Inoculum effect detected in 36% (MICs: $0.25-2mg/L \rightarrow 16-512mg/L$)

- 50% from osteomyelitis
- 33% blood cultures
- high prevalence in *S. aureus* with type A beta-lactamase

Conclusion: Is cefazolin really equal to cloxacillin??



Reduced subcutaneous tissue distribution of cefazolin in morbidly obese versus non-obese patients determined using clinical microdialysis

Margreke J. E. Brill¹+², Aletta P. I. Houwink³, Stephan Schmidt⁴, Eric P. A. Van Dongen³, Eric J. Hazebroek⁵, Bert van Ramshorst⁵, Vera H. Deneer², Johan W. Mouton⁶ and Catherijne A. J. Knibbe¹+²+[°]

JAC. 2014; 69: 715-723

 unbound (free) cefazolin interstitial space fluid (ISF) penetration ratio compared to plasma

AUC_{tissue}/AUC plasma

obese 0.70 (0.68–0.83) non-obese 1.02 (0.85–1.41)





Performance of Vitek 2 for Antimicrobial Susceptibility Testing of Staphylococcus spp. and Enterococcus spp.

April M. Bobenchik, Janet A. Hindler, Carmen L. Giltner, Sandra Saeki and Romney M. Humphries *J. Clin. Microbiol.* 2014, 52(2):392. DOI: 10.1128/JCM.02432-13. Published Ahead of Print 13 November 2013.

30 *S.aureus* isolates – inducible clindamycin resistance(ICR)
6 *E. faecalis* isolates –daptomycin non-susceptible

Results:

- 6 very major errors for ICR in *S. aureus*
- 2 very major errors for daptomycin

Conclusion: supplementary testing

- S.aureus clindamycin
- *E.faecalis* daptomycin



Evaluation of the treatment of vancomycin-resistant enterococcal urinary tract infections in a large academic medical center.

Heintz BH¹, Cho S, Fujioka A, Li J, Halilovic J. Ann Pharmacother. 2013 Feb;47(2):159-69.

Retrospective 3 year single center cohort study VRE urine cultures 269 episodes in 252 patients: 47%- ICU / 77% - admission \ge 7 days

Results:

- 58% asymptomatic bacteruria / colonization
- non-compliance 30% (83 cases)
 - 58% over treatment
 - 200 excess days of antibiotics (linezolid/daptomycin)- \$50,000
 - 42% under treatment
 - -antibiotics with no activity against VRE- mostly cephalosporins
 - -suboptimal dosing (daptomycin)

Conclusion: important opportunity for antimicrobial stewardship





Voided Midstream Urine Culture and Acute Cystitis in Premenopausal Women

Thomas M. Hooton, M.D., Pacita L. Roberts, M.S., Marsha E. Cox, B.S., and Ann E. Stapleton, M.D. N Engl J Med 2013; 369:1883-1891 November 14, 2013 DOI: 10.1056/NEJMoa1302186

236 episodes of cystitis in 226 women

- paired midstream urine (MSU)/catheter urine (CU) Culture Positive - 142 CU(70%) / 157 MSU (78%) MSU- *E coli*
 - highly predictive of bladder bacteruria
 - even at low colony counts (10⁵cfu/mL)
 - MSU Enterococcus spp (10%) / Group B Streptococci (12%)
 - not predictive at any colony count
 - 41 episodes MSU with enterococci/GBS \rightarrow 61% had *E coli* (CU)

Conclusion:

MSU cultures overcall enterococci/GBS in this patient population





Urine Is Not Sterile: Use of Enhanced Urine Culture Techniques To Detect Resident Bacterial Flora in the Adult Female Bladder

Evann E. Hilt, Kathleen McKinley, Meghan M. Pearce, Amy B. Rosenfeld, Michael J. Zilliox, Elizabeth R. Mueller, Linda Brubaker, Xiaowu Gai, Alan J. Wolfe and Paul C. Schreckenberger J. Clin. Microbiol. 2014, 52(3):871. DOI: 10.1128/JCM.02876-13. Published Ahead of Print 26 December 2013.

65 patients (41- overactive bladder / no UTI symptoms, 24- controls)

- Expanded Quantitative Urine Culture (EQUC) / 16SrRNA
 - O₂/CO₂/ANO₂/microaerophilic 35°C/30°C
- 52/65 (80%) grew bacterial species
 - 260 organisms
 - 35 genera/85 species

Conclusion: Need further studies to elucidate role of urinary microbiota in health and disease



Journal of Clinical Microbiology

PCR Based Techniques

Principle: sequence based amplification of nucleic acids

- *mec*A detection < 2 hrs
- vanA / vanB high false positive rate for vanB
- KPC/NDM/IMP/VIM/AmpC/TEM/SHV/OXA

Advantage:

rapid time to result

Disadvantage:

- presence of resistance genes may not always correlate with phenotypic resistance
 - PCR techniques relying on gene transcripts (RNA levels) potential solution
 - novel/undetermined mechanisms of resistance

Journal of Clinical Microbiology

PCR-Electrospray Ionization Mass Spectrometry for Direct Detection of Pathogens and Antimicrobial Resistance from Heart Valves in Patients with Infective Endocarditis

Cassandra L. Brinkman, Paschalis Vergidis, James R. Uhl, Bobbi S. Pritt, Franklin R. Cockerill, James M. Steckelberg, Larry M. Baddour, Joseph J. Maleszewski, William D. Edwards, Rangarajan Sampath and Robin Patel J. Clin. Microbiol. 2013, 51(7):2040. DOI: 10.1128/JCM.00304-13. Published Ahead of Print 17 April 2013.

PCR Based Techniques

PCR: ability to quantify number of copies of a specific nucleic acid

measure bacterial growth in presence of an antibiotic

Advantages:

- short incubation period to differentiate susceptible vs resistant strains
- not dependent on mechanism of resistance

Disadvantage:

- still require bacterial culture
- no testing directly from clinical sample (yet)



MALDI-TOF MS Based Techniques

Principle: differentiate spectra of resistant strains from susceptible ones Advantages:

- rapid
- highly automated

Disadvantage:

- may not correlate with phenotypic resistance
- strain variability may complicate interpretation

MALDI-TOF MS: an upcoming tool for rapid detection of antibiotic resistance in microorganisms.

Kostrzewa M¹, Sparbler K, Maler T, Schubert S. Proteomics Clin Appl. 2013 Dec;7(11-12):767-78.

MRSA

- differences in spectra due to clonality rather than mecA
- MRSA vs MSSA differentiation still not reliable
- Good epidemiological tool



MALDI-TOF MS Based Techniques

Functional assays to monitor enzymatic activity

Beta-lactamase

- enzymatic cleavage of beta-lactam ring characterized by addition of a water residue increase in molecular weight of the antibiotic
 - no change in MW if beta-lactamase negative
- ratio of peak intensities between hydrolyzed and non-hydrolyzed:
 - resistance quotient (RQ)
- rapid (1-2 hr):
 - based on enzymatic activity not bacterial growth



Journal of Clinical Microbiology Evaluation of Matrix-Assisted Laser Desorption Ionization–Time of Flight Mass Spectrometry for Rapid Detection of β -Lactam Resistance in Enterobacteriaceae Derived from Blood Cultures

Jette Sophia Jung, Christina Popp, Katrin Sparbier, Christoph Lange, Markus Kostrzewa and Soeren Schubert *J. Clin. Microbiol.* 2014, 52(3):924. DOI: 10.1128/JCM.02691-13. Published Ahead of Print 8 January 2014.

100 Blood Cultures:

- detection of 3rd generation cephalosporin resistance in 2.5 h
- cefotaxime as indicator drug
- previous studies :
 - ceftazidime- false negative with ESBLs/AmpC
 - cefpodoxime- false negative AmpC

Resistance detection: sensitivity/specificity

- aminopenicillins 100% /100%
- AmpC 100%/91.5%



Journal of Clinical Microbiology

MALDI Biotyper-Based Rapid Resistance Detection by Stable-Isotope Labeling

Katrin Sparbier, Christoph Lange, Jette Jung, Andreas Wieser, Sören Schubert and Markus Kostrzewa *J. Clin. Microbiol.* 2013, 51(11):3741. DOI: 10.1128/JCM.01536-13. Published Ahead of Print 4 September 2013.

single labeled amino acid- assay more cost effective

- growing bacteria incorporate labeled amino acid
- H/N ratio- heavy peak/normal peaks

28 strains of S. aureus:

Detection of resistant organisms after 3 hours

- good correlation with routine results
- need good growth characteristics

Conclusion- Proteonomic approaches can detect biological activity not possible with genetic techniques



Microarrays

Principle: identify presence of specific nucleic acid sequences using complimentary oligonucleotides

assemble oligonucleotides onto solid supports in close proximity:

Advantages:

possibility of creating arrays to detect broad range of resistance genes

Journal of Clinical Microbiology

Potential Impact of a Microarray-Based Nucleic Acid Assay for Rapid Detection of Gram-Negative Bacteria and Resistance Markers in Positive Blood Cultures

Nicasio Mancini, Laura Infurnari, Nadia Ghidoli, Grazia Valzano, Nicola Clementi, Roberto Burioni and Massimo Clementi J. Clin. Microbiol. 2014, 52(4):1242. DOI: 10.1128/JCM.00142-14. Published Ahead of Print 29 January 2014.

102 blood cultures : CTX-M, KPC, VIM, OXA

detected in 29.8% of isolates

Results:

Enterobacteriaceae: PPV 95.8% NPV 100% *P. aeruginosa:* PPV 100% NPV 78.6%

Microfluidics

Principle: miniaturization of molecular assay utilizing very small amounts of reagents/analyte

- multiple functionalities on a chip including bacterial culture, nucleic acid hybridization/amplification and cell lysis
- detection- electrochemical/magnetic/optical

Advantages:

- highly automated /very rapid results
- very small amount of analyte / small size of chips:
 - potential for portable device
- measures growth:
 - more likely to correlate with phenotypic resistance
 - detect resistance not previously described



Microfluidics

Rapid antibiotic susceptibility testing by tracking single cell growth in a microfluidic agarose channel system.

Choi J1, Jung YG, Kim J, Kim S, Jung Y, Na H, Kwon S.

Lab Chip. 2013 Jan 21;13(2):280-7.

can approximate MICs in 3-4 h



J Urol. 2011 Jan; 185(1): 148-53.

A biosensor platform for rapid antimicrobial susceptibility testing directly from clinical samples.

Mach KE¹, Mohan R, Baron EJ, Shih MC, Gau V, Wong PK, Liao JC.

electrochemical quantification of 16SrRNA measured bacterial growth in presence of antibiotic directly from clinical sample (urine)

- result in 3.5 h
- 94% agreement with standard AST

Cell lysis-based approaches

Principle: detection of bacterial cell lysis after incubation and immobilization in an agarose microgel

- immersion in lysing solution results in disruption of the nucleoid in bacteria
- incubation with DNA fluorescent stain where nucleoid integrity visualized by microscopy

Advantages:

- determination of MIC possible -nucleoid fragmentation visualized after incubation with different concentrations of antibiotics
- detection of resistance regardless of mechanism of resistance

Disadvantage

Studies from pure bacterial cultures

Journal of Clinical Microbiology Rapid Ertapenem Susceptibility Testing and Klebsiella pneumoniae Carbapenemase Phenotype Detection in Klebsiella pneumoniae Isolates by Use of Automated Microscopy of Immobilized Live Bacterial Cells

Carey-Ann D. Burnham, Rachel A. Frobel, Monica L. Herrera and Brian L. Wickes *J. Clin. Microbiol.* 2014, 52(3):982. DOI: 10.1128/JCM.03255-13. Published Ahead of Print 3 January 2014.



Whole-genome sequencing

Principle: rapid sequencing of whole bacterial genomes with potential for current bio-informatic tools to assemble and analyze data

Advantages:

completeness of data

Disadvantages

- need to develop resistance gene prediction method
 - address complex interaction between transcription/promoters/repressors regulatory molecules

Unlikely that whole gene sequencing will replace phenotypic methods

Journal of Clinical Microbiology Prediction of Staphylococcus aureus Antimicrobial Resistance by Whole-Genome Sequencing

N. C. Gordon, J. R. Price, K. Cole, R. Everitt, M. Morgan, J. Finney, A. M. Kearns, B. Pichon, B. Young, D. J. Wilson, M. J. Llewelyn, J. Paul, T. E. A. Peto, D. W. Crook, A. S. Walker and T. Golubchik J. Clin. Microbiol. 2014, 52(4):1182. DOI: 10.1128/JCM.03117-13. Published Ahead of Print 5 February 2014.

Whole genomes of 501 unrelated S. aureus and validation with further 491 strains

sensitivity 97% / specificity 99% compared to standard AST



Progress on the development of rapid methods for antimicrobial susceptibility testing.

Pulido MR¹, García-Quintanilla M, Martín-Peña R, Cisneros JM, McConnell MJ.

J Antimicrob Chemother. 2013 Dec;68(12):2710-7.

Rapid Antimicrobial Susceptibility Testing:

- Sensitivity and specificity remain to be determined
- Clinical validation studies yet to be performed-error rate (VME/ME)
- Level of discordance between presence of resistance determinants and phenotypic resistance
- How will novel/undetermined mechanisms of resistance be addressed?
- Level of qualification for technologist/cost per test





Microbiology news that might make you an interesting dinner guest











NATIONAL*POST

'Massive' outbreak at world famous Noma restaurant sickens 63 people in Denmark

Pygsuia biforma: Biologists Discover New Amoeba-like Organism in

Massachusetts



This is a false-color micrograph of *Pygsula biforma*. Scale bar – 2 μm. Image credit: Matthew W. Brown et al / Proc. R. Soc. B.

According to the researchers, the newly discovered species, named *Pygsuia biforma*, will help them understand the molecular mechanisms and ancestral genetic toolkit that enabled animals and fungi to evolve into diverse, multicellular life forms.

Scientists Discover New 'Giant Virus' in Melting Siberian Permafrost

Thirty-thousand-year-old distant relative of giant icosahedral DNA viruses with a pandoravirus morphology

Matthieu Legendre^{a,1}, Julia Bartoli^{a,1}, Lyubov Shmakova^b, Sandra Jeudy^a, Karine Labadie^c, Annie Adrait^d, Magali Lescot^a, Olivier Poirot^a, Lionel Bertaux^a, Christophe Bruley^d, Yohann Couté^d, Elizaveta Rivkina^b, Chantal Abergel^{a,2}, and Jean-Michel Claverie^{a,e,2}

Proceedings of the National Academy of Sciences of the United States of America. Vol 111 No 11, 4274–4279.



Pithovirus sibericum

Researchers prove the five second rule is real



Food picked up just a few seconds after being dropped is less likely to contain bacteria than if it is left for longer periods of time, according to the findings of research carried out at Aston University's School of Life and Health Sciences.

E. coli bacteria

