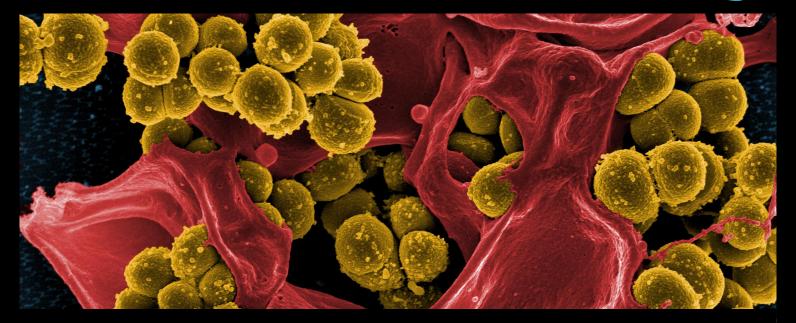
Science Fair Research * IB Biology 1



Miss Ronan & Ms. Toledo * Fall 2017

You can make a difference!



What is scientific research?

Scholarly / Academic Resources

- * Written by an expert
- * Checked by experts
- * Higher level analysis
- * Vocabulary used by experts
- * Written with the expectation of prior knowledge

Popular Resources

- * Usually written by a journalist
- * Checked by editors
- * Mass readership
- * Popular / everyday vocabulary
- Usually no prior knowledge necessary

How do I read scientific research?

The Structure of a Scientific Article



plus coastal ocean outlide mately 10 TW at 100 m o Antarctics, and approximately Thus, there is no fundamental 90 km in the jet streams. obtaining half (approximately 175 W) or sewnal t d) al-purpose power

"The abstract is a summary of the paper. [It] will help you decide if the article was what you were looking for...without the concernt spending a long time reading the whole paper." Read this first.

At the SWPF winds atili owns because individual turkines can around base extract so more than 59.3 % of the kinetic energy in the wind (Betz's limit). This paper also defines the fixed wind power potenhai (FWPP) which is the maximum power that can be extracted aloh, ex by a fixed number of wind turbines at decreasing installed density dependent increasing geographic area. The SWPP is calculated here at 100 m above ground, the hub height of most modern wind tur- energy of bines, assuming conventional wind turbines distributed every-country where on Eath, iscluding over the oceans (simulation named "global-SWPP") and, separately, over land only but excluding Autustica ("land-SWPP"). The SWPP is also calculated at 10 in above ground in the jet stream assuming althouse wind a clectricity devices (*jet stream-SWPP*). Capturing jet stream which piet to combu

The main purpose of these simulations is to use a physical model to determine the theoretical limit of wind energy available at these altitudes, particularly because some recent studies that (via conversion of internal energy to pome available potential accounted for energy extraction by furtines, but not physically, have suggested that available windenessy is small (2, 3). Previous theoretical estimates of the power in the wind (4-9) are nimilarly not based on a physical mode of energy extraction so cannot give estimates of wind potential at the height of turbines. As found here, energy extraction at a given altitude does not deplete energy at all altitudes above or below it so an extinute of wind notestial the whole atmosphere does not answer the practical question about wind turbine potential at typical bub heights.

More relevant for oractical applications, the FWPP of four mil-

lion turbines at 100 m in three different configurations is quantified here to determine if this number is sufficient for powering half the world's all-purpose power demand in a 2030 clean-energy

Publication Informationmany of the details here will be used in your citation

accounted for. This information is critical for determining the feasibility of a worldwide reasonable energy fature. Calculating the SWPP for large penetrations of wind (>1 TW) is not cur rently possible from data analysis, because generations are still low (239 gigawatts (GW) installed worldwide at the start of 2012) The most accurate method available to analyte this issue is with a complex 3D atmospheric-ocean-land onupled model.

Previous global simulations of wind farms have assumed that wind farm effects on the atmosphere can be represented by changing surface roughness or adding a drug coefficient (2 13-17). Roughness parameterizations, though, incorrectly reduce wind speeds the most in the bottom model layer, whereas in reality a surface wind turbine reduces wind speed the most at bub height. approximately 100 m above ground (Fig. 1). Hecause mughness tengths and drug coefficients are approximate, it is also difficult to ensure they extract the correct amount of energy from the wind. Calaf, et al. (18) demonstrated the inacountry of standard rough the number of these parameterizations against large-oddy simulation results surbinor further does not increase the generated power further. and developed a multiple large roughness parameterization for

> "Reading the introduction is a test of whether or not you are ready to read the rest of the paper; if the introduction doesn't make sense to you, then the rest of the paper won't either."

sents greater technological challenges than capturing surface pollutants (10, 19). As such, wind turbines reduce direct less winds but in still of interest (1, 2). and pollutantemissions compared with conventional generators. However, the electricity use util needs to be accounted for heenergy to kinetic energy). To date, only set, I has calculated the heat from electricity returned to the air, but they focused on airhome rather than ground-based wind turbines.

> Author contributions MELL and CLA, designed research; MELL and CLA performed reservity N21 contributed newerogenstanally foctool; M21 and CLA, analyzed data and M21 and CLA, write the paper. The author declare no conflict of innered Philadide da Histi Diret Subrito da Malak is a guest e

Author Information and credentials The aticle contains exporting information broke at weeepoutorghydruphupoli doi:10.1077pnw.50999709v03upd-medai.

15% 2530 4-YAR DOTW -world(S,738 TW) (WTMC) Cheek Persont change in world wind speed (% Fig. 1. Comparison of heights and magnitudes of globally averaged percent windspeed reduction averaged over one year from (A) the turbine momentum sink parameterization presented here vs. (0 the latter (10 surface coughness parameterizations, is both case, the world is covered with either 11463-83 or (size, world, 124.5 million (green, lend), or four million (e.d. 50% of 2000 power dense of) 544 married 0.64 km² a.m.t. A list stream on a laukinolitouse in (4) for 911 million (Nack) SAMM economic somilistics ratio vertical profiles between the world (Simulation 81) and (8, and left

Week(3,72) TW

Tand 5,620TW)

Here, the GATOR-GCHOM global model (10, 21) is used to exemine settingtion and filed wind sower potentials, the model is modified state turbines as an elevated momentum sink, wherethe lines from the wind a determined from a turbine power curve at the instartare our model wind speed. The treatment of turbines developed is concep-tually similar to that in (22, 23) but differs as follows: (i) it assumes each wind turbing controls multiple vertical attracebasis laws, rather than one liver, (i) it is equiled to summous wind forms worldwide simultaneously turn extraction feeds back to global dynamics rather than a limited-way mandal with and uncertained for subsides, and City II consiste for an one- remained tion due to bothe lectricity use and fur buient discipation of kinetic events in extraid energy from four points on a staggered Avakawa C srid, thereby impacting five oils simultaneously, rather than from the center of the cell, affecting only that call.
The St Materials and it

"The results section...contains all the data from the experiments." This section might include charts, tables, graphs, and written descriptions.

mughtes to turbulence, then heat.
Table I summerize the simulations. A control of with technique at 100 to both belief but no momentum as In this paper, the global capacity factor was about 31% bas adon in ta "The materials and methods section gives the technical details of how the experiments were carried out."

- World

to determine the PMPP of four million SMW turbines, the number estimated to supply helf the world's elecutions down in a deep energy acall and ISS-605 and ISV-6636N, and below 3 km attrace (Smulation N) over eight land and coatal ster (fable 1, fost note) (C); and over three land ster (fable 1, footnote) (P).

Inally to determine the SAFF of the let streams (15-705 and 10-725) a lation (ii) werrun, A 1.5" x 1.5" simulation (ii) was also run to sally result

All simulations included 68 vertical sigma-or essure laverage to 0.219 hPs (util km) including 15 layers from 0-1 km and 503-m resolution from 1-21 km. The center of the lower model layer was 15 m shows ground The notion of each surface bubble (simulations 8-P) interested five mode layers. The model was run forward from January 1, 2005 with no data assimto the king computer time required for netletive, cloud, seroed, and ga five years was similar and convergent in all simulations.

Fig. 24 shows that, up to about 715 TW (1.4 W/m²) of installed power, the output from power-estracting wind turbines first increases linearly. The linearity is demonstrated by comparing the initial slope of the "global SWPP curve" (with power extraction with the slone of the "global-no nower extraction" line. The latter is the line between zero and the power output from Simulation A which is the reference case with turbines but without rower action. At higher penetrations, power output increases with ing returns until it reaches global saturation (approximately 253 TW also Fig. SiB for orange-resolution results) at "x " haizontel resolution sessibility The species and with decreasing intrafect about 1,870 TW (5.65 W/m²) installed. Higher penetration power density, were run. Smulestons (4) (2.5" x 2.5") and (6) (1.5" x 1.5"), of wind some no additional benefit. Thus, for the first 715 TW

a of a | www.pras.orgic.grazzno.nemap.cu.razzonemana www.pn s.org/glido.VO. 1077/pnas. (20090) 109 PNUE Darky Edition | 1 of 6

How do I read scientific research?

The Structure of a Scientific Article

total power in that region (100 TW) multiplied by the fraction hydrogen (10). Fig. 20 shows that the power output of from that could interact with wind turbine rotors (<0.3), the fraction million turbines increases with decreasing wind turbine spacing in the range of turbine out in and out out speeds (0.75), and the When turbines are packed at an installed density of 11.3 W/m traction converted from kinetic to electrical energy (0.3). These into three sites worldwide, the power output is too low (approxifactors were all accounted for in time and gaze in the circulations: mately 1.6 TW. Table 1 and Fig. SIF to match power demand As here. The large difference highlights the importance of using eight locations (5.6 W/m2 installed), the output improves to

The SWIT over land cutoide Antarctics here was approxi- However, when furbises are spread motely 72 TW (Fig. 3d and Fig. SSC). Rased on the high resolu-tion global-SWP7 calculations here, another approximately 8 TW (0.11 W/m² installed), the output was available offshore at depths < 200 m, giving a land plus coastal SWSP artinate of 80 TW. Like with the global case, the land-SWPF curve (Fig. 1.4) shows a linear portion at low turbine to spead turbines erests across such dininshing returns set in. However, the full land-SWPF was not able spreading between fams occuhts.ined until a ppentinutely 1,500 TW (11.3 W/m²) of installed power. The result here suggests that bottom-up approaches for accounting the higher model resolution calculating wind power potentials over land are justified for

The land SWIP is not much lower than the 12 TW of outhors ower from a study (25) that assumed a fixed percentage energy loss due to turbine interference but not increasing competition for wind with increasing turbing constructors. Results from (2) fall near the linear 'global-no extraction' curve in Fig. 24, above the land-SWFP.

Another study (26) eximated the world land phisocosts otendal based on world counting and corfuce data a initiarly, ref. 25 estimated a land potential of 78 TW. factors of 20% or higher. Both studies accounted tions with mean annual wind speeds before exand did not account the income! setting factors caused their results to be similar A GW PP (72 TW) and the land plus near-shore ex K mately 80 TW) found hore. If only 50% of land-hared wind wy

locations (3) the feasible wind onto

"The discussion section is the authors' opportunity to give you their opinions...[and] draw conclusions about the results."

Albome jetstream turbines would require energy to ascend and descend and may not overate all year. This analysis does not quantify such losses, only extractable energy.

The estimatable power globally at 100 m and, reparately, at 10 km in the jet streams, are both independently less than the sity above the turbine comerline than below (28, 29). While such total extractable power in the wind at all altitudes, estimated broady as 450-3800 TW (4-9). These previous studies, though, concert to downward number of fuzer winds from a left into the did not consider extraorpor at a single attitude, such as the height. Write Blade generated turbulence is transported vertically due to of modern wind turbines nor did they use a 3D model to make their estimates. Extraction of power at each 100 m and at 10 km ambient turbulence rather than on its own (28). As such, bladelocs not give the same chalpation as complete extraction of kinetic energy from the atmosphere, as seen in Fig. 1: instead. eath esuits in wind reduction over a vertical segment of the atmosphere, decreasing with distance from the height of estruction. relation N.P examine whether approximately four reliion 5-MW turbines (20 I'W installed) can provide at least 5.75 TW reaches the ground, it may largely be offset by reduced she army of delivered power, enough to supply 50% of all-purpose endstress below the turbine caused by reduced wind speed in the use power deniand in 2039 for a works energy intrastructure wake resulting in little net surface turbulence, consistent with the converted to wind, water, and conlight (WWS) and electricity/ abreementiced: measurements (39). Both the educed wind

approximately 4 TW (Fig. SSE) but

References: The numbers connect to the citations an installed density of approximate included at the end of the can have installed densities of 5.6 article. density within and between farmain

na interference of one turbine results here sugget that staggering sobjects improved the overall pose the nower notestial of a fixed number of output. In other wor with increased spreading of famou. The addition of surface wind furbines reduced horizontal

wind speeds in their vake We most and fellow and above the wake centerline to a lesser opent (Fig. 1.4). The reduction in wakewind need reduced shealing stress below and increased it results (18). Greater shearing stress above the wake increased subgrid-scale turbulent kinetic energy (TKE) fliere, increasing the downward transport of horizontal inconentum from above to the turbines. Downward transport & horizontal momentum to a turbine wake was also increased in the model by subgrid-scale thermal turbulence and grid-scale gravity caves when they were present. Lesser shearing stress below the wake documented TKE and downward momentum floor near the nation, ar in set 10.

Exaporation rates are proportional to both sectice wind speed and surface shearing stress, and both decreases in all surface turbise simulations, reducing evaporation and water super (e.g., Fig. 1(1). These calculations were all made with the in ving the bottom kilometer with 15 vertical layers, including five layers interacting turbine rotors.

Drag from blade rotation and creates turbulence is of small analy vartices that can enhance mining. This nec lanism has been suggested by ref. 27 to explain why wind turbin creare downwisd surface temperatures during the fax when \$ lapse rate is generally unstable, and slightly increase them night, when the lapse rate is generally stable, but winds at hi reight are stronger. However, blade-generated traffulence under neutral conditions is observed to be transported and disspate downwind is a spiral motion (28), with one ger turbulence intenturbulence reduces mean wind speeds in the wate, it also in shear turbulence generated by the velocity deficit in the wake and above the centerline and surface and little may set to the surface. modeling (figure 1 of ref. 29). This result may differ under very unrable conditions. Even when blade-senerated terbulence

speed and small turbulence chause sear the surface due to turhe source horizontal resolution of the model and the simplification of so turbise-rotor generated turbulence.

Reduced evaporation reduced evaporative cooling of the surhoe, first warning the nurthon. However, because evaporated aster sensor normally recondenses in the atmosphere to fortoids, releasing latent heat there, the reduction in water vapor rapor in a greenhouse gas, suducing it increased thermalradiation escape to mace, cooling the surface further. Howless water also reduced cloudiness, increasing solar radiafrom in the outline cluster during the day but increasing outgoing ice above that Enhanced clouds are improved presimilation thermal-IR at night, thus causing a slight warming at night, as oberved (27, 30). The net offeet of all five changes jair cooling due to lower atmospheric latent lead release, ground warming due to (Fig. SSP). Compressional leading over the poles increased lower surface water reasonation, air and ground cooling due to a temperatures there, but the not effect of int stream turbines was reduced water vapor greenhouse office, ground warming due to nurface cooling by > 1 K (Fig. 53°), as sold air advection from the reduced dwarfer upon ground confine, now a rectified the produced anything cloudiness) was a ground confine arrive our few anything time cloudiness) was a ground savinged surface or tem-nishtrine cloudiness) was a ground awarded surface or temsenture decrease in 15 out of the 16 purpose trubine circulations. This result is expected because watervapor isknown to cause set column supor at low latitudes (Fig. S/F). warming of the strassifiere, so extuding it should cause occling (31). Emperature results, though, are still uncertain, particularly due to the uncertainty of clouds and the transiest nature of the devolutions and could chause over longer devolutions became efit of the slower winds, though, is the reduction in wind-driven coll dag, on gray, and opera, pollen, and bacteds enjocions. reducing human exposure to small particles that penetrate deep

Globally distributed turbines decreased zonal winds: however. they increased mentional winds in the pole-ward direction in both hemispheras (Fig. S4.4 and B). The pole-ward transport of air increased the pressure gradient between the poles and Equator by approximately 13-23 hPs, apporting the contention that the atmosphere seponded to the increased dislipation of kinetic energy by increasing some of its available potential energy via enhanced pore-to-Esquator pressure gradients. Reduced water vapor partial pressure at low latitudes contributed slightly to the enhanced pressure gradient.

- 1. Arther Ct., Clide's K. CROB Gobal sovement of high-elthode wind power. Energied
- 2 Miller IAL Ganof-Kleichn A/2011 Jet tream wind power ara recovable energy
- mouse: Little power, tig impact. Birth Syr Syrus 2001-20.

 1: De Carro C, Mediarilla M, Missel U, Rednobil Offil) Global wind power potential and technological limits (Rednobil) 19667-4668.
- A TURNOS (TICL) The Native and Thomp of MacCanana Constitution of the Americana (MMO, General) p.168.
 - 6. Polycon R. Care As F199C1 Physics of Cityan City and con Institute of Physics, See York 1.
- Summon II (BDQ Renmable Energy Its Rysis, Jagineering, the Endonmentalize ock approve and Marring Appelling Byter Academy Rep. London, 12 and 14 fb. L.E., Ingercolies, Sing X. Pelderan C, Yung YS. (2007) concrewings gate of the global armogness based on nonaligic disease. Geographic committees of the global
- is Stately (C), David RM (2006) Physicsof the Jamb (Sanbridge Univ Rest, Cambridge). (i) books (M.) Dakoti MA CHILI Soul does all stokel assess with used water and cocon multi-micro situ pritti processing a good energy with wind, water, and the power, part l'Technologies, evergy weathers, quantities and areas of influence-res, and impacts, (every insign 54+194-150).

 21. Biothorn MJ, in Howe S (\$05) (Bhict columns surface and with most co-global

ow DJ (1980). The performance of satural of wind furbines. J Wind ling and

Called SM QXX (B Edmarting power outpathon a tide connect subine farmed th EMBY 2 ST-19.

Global warming increases temperatures at the poles more than sines contributed in the model to reducing surface emporation. lower latitudes. The temperature gradient reduction could re-Uncertainties in the treatment of turbulence still exist fact o both duce slobal man surface wind resources in the future although ocean wind reproces over the bat 23 years have increased in the global average according to multiple datasets (32). Higher water vapor due to fatue warming will also likely offset educed water

let atteam turbines reduced mean point meads at although above and below them, but increased boundary layer wind sneeds ced latest heat release in the air, cooling the air dise at a (Fig. 12.) Like in the surface one, turbines decreased amal wind at of this pencess. Because water vapor contributes to air pres-speeds substantially (Fig. SSA), but increased mendional wind reducing water vapor also reduced globally averaged air speeds (Fig. 338), moving air pole-ward at 10 km but equatorure by approximately 0.3 and approximately 0.1 hPs in the ward near the surface in both temispheres following the experal (Sinulation B) and land (I) cases, respectively. Because the pressure gradients (Fig. S/C). Lower surface measure in the tropics through midhattudes caused at to rise, expand, and co adiabatically, decreasing temperatures at all abitudes (Fig. SSII) and increasing both cloud liquid below 5 km (Fig. St.E) and cloud and both, together with net divergence, decreased vater vasor in the tooks and subtooks and increased it toward the poles ton of that vapor decimand

The reference section lists the sources the authors used each in their research. "Use these recommendations for other articles you can refer to for additional background reading."

150, 111,1015-8120

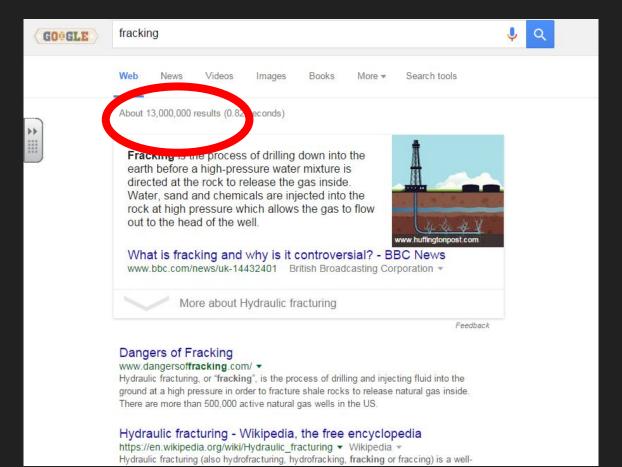
White I is the Common of the Common of

- C. J. Attendo S. (6):2315-1234. Barria D, sibil-Emakkitt DE (2001) Wassingt response to a large wind talking army Attoo: Own Plus 18799-175 Waste C. Mirardi, \$4.90 Promoted a limital impacts and reliability of one large such wind \$40%, Across Chert Place \$12003-2011.
- 7. Miler ISV, Gent F. Keidov A (0111) attinuating maximum plobal land surface wind power extracted by and associated climatic converguence. Birth fact flamous 2:1-12.

 16. Calif M, Mengelau C, Meyers J (2010) large eddy circulation study of fully developed.
- Sta-Mad a MRV, Jacobson M2 (2009) Investigating the effect of large wind drive on 20 Baban NC, Wileson J, Naissan AG, Lee SC (2011) Therefore of sinced on cinace and potation, rant i truspenda methods for treating the subgrid exolution is donte ore ad composition-ecologi contrals from all commercial lights world-wice. J Corp. High 2005 151–6162.
- and regional directs J Circums 25:10:0-10%. 2 Stalified Day S. Becalle SW. Wellin St. Child's Care large, wind former officer local memory. plans / Geogra Res 1092-1918
- J Wind English Award 99/91-499

FRANCISCO I DISCO

4 of 6 | www.prost.org/cg/doi/10.1073/b sas (200997) (39





Welcome to the GCM Library

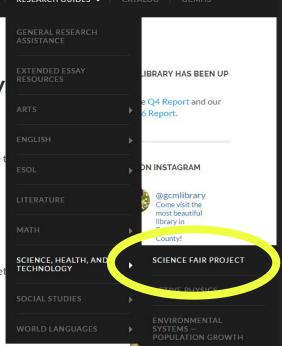
Learn in the Library

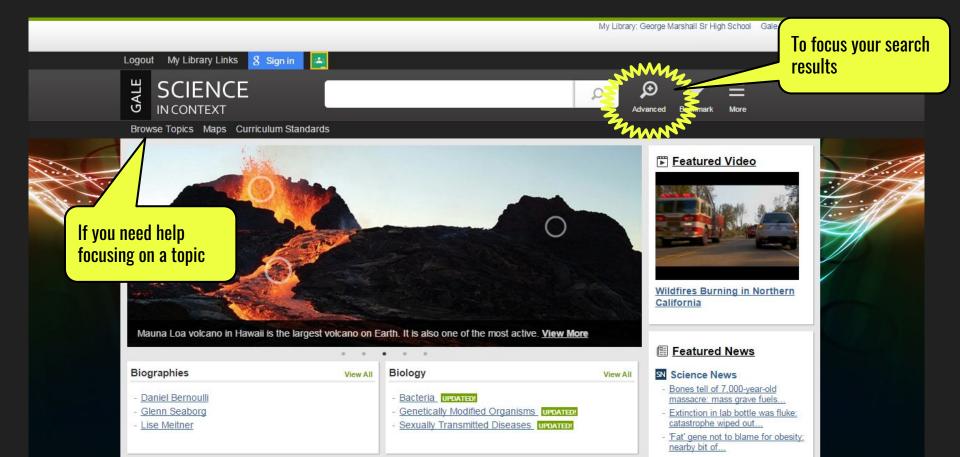
For the new school year, there are some changes to how students use t Library during Learn to ensure that we provide a productive learning environment.

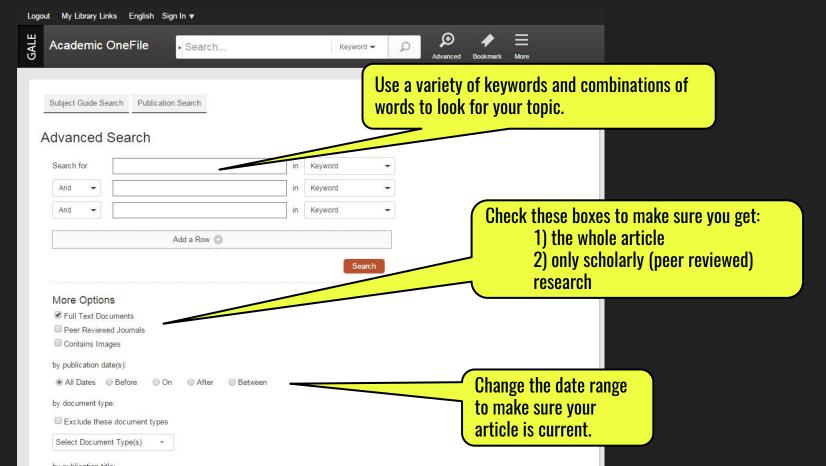
- Limiting # of Students to 150
- · Students Need a Ticket to Get In

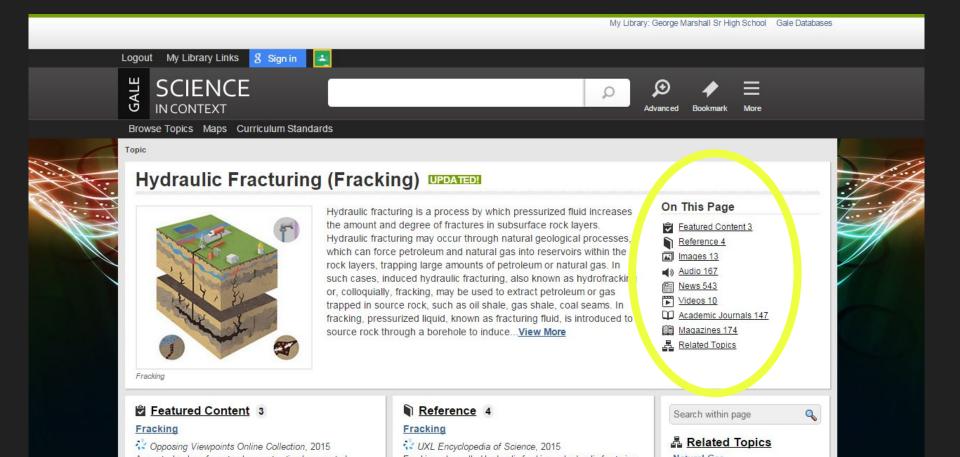
We will distribute 150 tickets for each Learn. Students can get a ticket the library the day before or morning of each day's Learn.

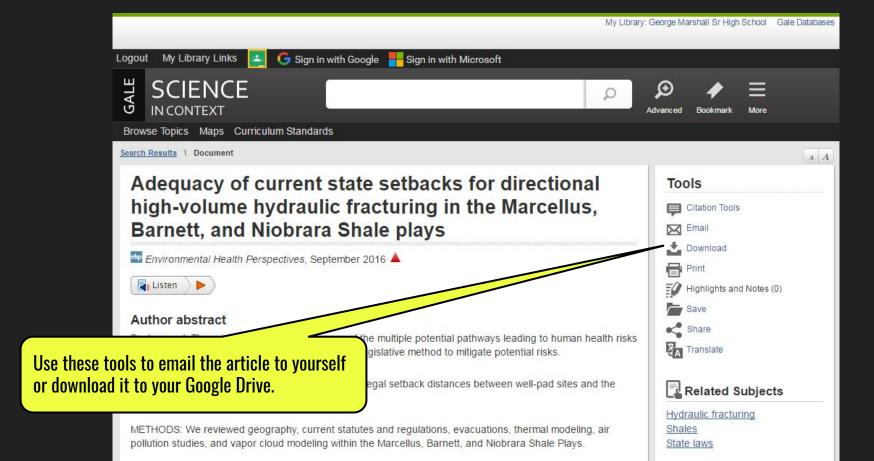




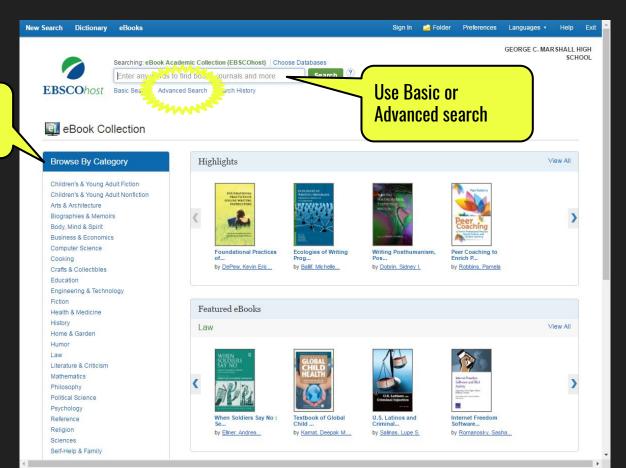








EBSCO eBook Academic



Browse by category

Science News

Get login information from Blackboard

Browse by topic

Search function Science News for Students Student Science Log Out Love Science? Welcome Home. Support Amazing Science Journalism. **ScienceNews** Create the New Science Generation. Search Science News... LATEST MOST VIEWED New case emerging for Culex mosquito as unexpected Zika spreader First 'three-parent baby' born from nuclear transfer Measles has been eliminated in the SPREADING NEWS The controversial idea that a Culex mosquito (shown) can spread 7 ika is getting some reconsideration as new Americas, WHO says NEWS IN BRIEF Barnacles track whale migration FOR DAILY USE Wi-Fi can help house distinguish between members **Science News Blogs** First 'three-parent baby' born from

nuclear transfer

Login

Enter your Science News in High Schools account information digital access

USERNAM

PASSWORD*

TRACKING CODE*

Interested in an educator guide for Science News? Sign up for the newsletter.

Log in

Works Cited

National Institute of Allergy and Infectious Diseases. "Micrograph of Methicillin-Resistant Staphylococcus aureus (MRSA)." Online image. Flickr. Yahoo!, 30 June 2006. Web. 1 Oct. 2015. https://flic.kr/p/dRtGwW.

Prata, Andre. "Piled Vitamins." Online image. *Flickr*. Yahoo!, 18 Apr. 2011. Web. 23 Sep. 2015. https://flic.kr/p/9zxm9v.