What will you die of?
&
Health in 2030

Week 4 Lecture 2

Before we go down the technology rabbit hole...

We need to talk about the *economics* of technology

Otherwise, very little makes sense

Newspaper headlines

Starvation

Global warming

High drug prices

New dangerous diseases

And more...

Global warming (bio)tech

If you are a (bio)engineer, then in three minutes, you can think of ways to address global warming:

- Sunlight and CO2 to biofuels
- Use Photovoltaics to split water, make Hydrogen
- Collect CO2 from atmosphere and store deep underground

SCOTT KIRSNER | INNOVATION ECONOMY

How a biofuel dream turned into a nightmare

COURTESY OF JOULE UNLIMITED

Joule was designing a system that would produce diesel fuel or gasoline using nothing more than the sun, carbon dioxide, water, and a genetically modified bacterium.


There is one tiny little problem

Deals

Aramco Pumps Oil at Fraction of Rivals' Costs and Way More of It

By Anthony Dipaola

April 1, 2019, 6:24 AM PDT

Updated on April 1, 2019, 2:00 PM PDT

- Cost of extracting crude is $2.80 a barrel: bond prospectus
- Production is more than 5 international oil companies combined

Source: Aramco bond prospectus, Bloomberg
Note: Some data provided by person who saw presentation for investors


Global warming tech
Self
Chevron
Food Mart
Gasoline Self Serve
Regular 449 9/10
Plus 469 9/10
Supreme 489 9/10
Diesel No. 2 469 9/10

Global warming tech

00 PM PDT

de i $2.80 a barrel bon

an 5 international oil co

1 barrel = 42 gallons

42 gallons at the pump = $189

$189/2.80 = 6650% profit

Global warming tech

Cost to extract crude from the ground
$0.06 per gallon

6650% profit

100 fold difference

56% profit

https://www.card.iastate.edu/research/biorenewables/tools/hist_bio_gm.aspx

Cost to make 'crude' at the plant
$3 per gallon

Global warming tech

Competitiveness: Biofuels vs Petroleum-based fuels

Compared to biofuels, the refining of petroleum is less expensive as it is highly optimised and nothing is wasted. Projections of price and technology development that show that advanced biofuels could be competitive with fossil fuels on a volume basis, but timing ranges from 2020-2030 and at an oil price ranging from US$70-US$150/barrel. At a low price of US$60/barrel only conventional biofuels such as sugar cane ethanol can currently compete directly on a volume basis[10].

As technology advances, biofuels can come to the market at lower costs, with a lower environmental impact and higher GHG reductions. As seen with conventional biofuels, a cost reduction of between 1.5-3 times can be achieved in 10-20 years[11].

http://www.biofuelsforeurope.eu/cost-competitiveness/

What's the issue with this calculation?

Prediction - Biofuels will compete with Aramco in 90 years assuming production cost goes down by 1/2 every 20 years

2030 - $50
2050 - $25
2070 - $12.5
2090 - $6.25
2110 - $3.13

Newspaper headlines

Starvation

Global warming

High drug prices

New dangerous diseases

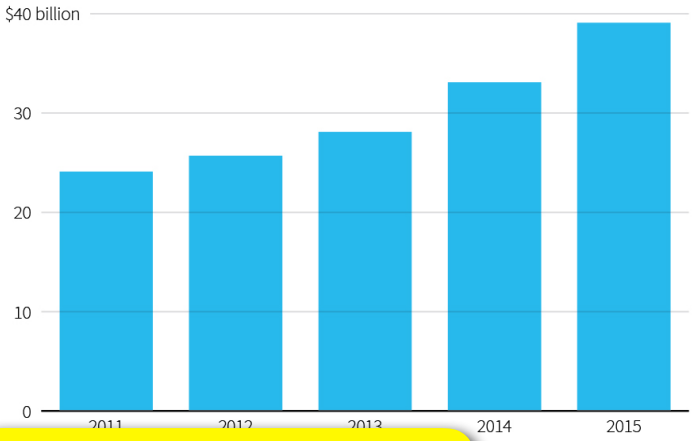
And much more...

Drug (bio)tech

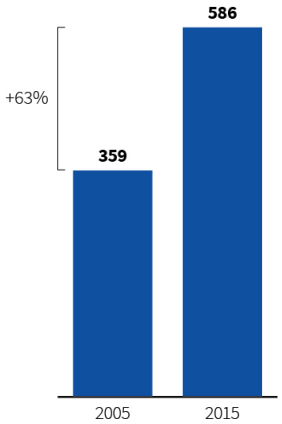
Oncology drug prices

Scientific progress, pricing power, drive pharmaceutical companies to emphasize oncology research.

U.S. SPENDING ON ONCOLOGY MEDICINES



NUMBER OF CANCER DRUGS IN CLINICAL DEVELOPMENT



PD1/PDL1 CHECKPOINT INHIBITOR PRICES
Estimated average per month*

Opdivo	Keytruda	Bavencio**	Tecentriq
BRISTOL-MYERS SQUIBB	**MERCK**	**PFIZER**	**ROCHE HOLDING**
$13,100	$13,000	$13,000	$12,500

* Drug price is based on the milligrams of medicine used and varies with the weight of the individual patient.
** Bavencio's price is the wholesale acquisition cost for an average patient.
Sources: QuintilesIMS Institute ; Reuters

C. Chan 30/03/2017

REUTERS

Drug (bio)tech

Use bioengineering to make cheap drugs that everyone can afford!

Drug (bio)tech

Let's look at manufacturing costs...

Appendix A
2018 Financial Report

Words that do not appear in the report:

Cost of goods sold (GOCS)

Materials

Manufacturing cost

Drug (bio)tech

ANALYSIS OF THE CONSOLIDATED STATEMENTS OF INCOME

(MILLIONS OF DOLLARS)	Year Ended December 31, 2018	2017	2016	% Change 18/17	17/16
Revenues	$ 53,647	$ 52,546	$ 52,824	2	(1)
Cost of sales	11,248	11,228	12,322	—	(9)
% of revenues	21.0%	21.4 %	23.3%		
Selling, informational and administrative expenses	14,455	14,804	14,844	(2)	—
% of revenues	26.9%	28.2 %	28.1%		
Research and development expenses	8,006	7,683	7,892	4	(3)
% of revenues	14.9%	14.6 %	14.9%		
Amortization of intangible assets	4,893	4,758	4,056	3	17
% of revenues	9.1%	9.1 %	7.7%		
Restructuring charges and certain acquisition-related costs	1,044	351	1,565	*	(78)
% of revenues	1.9%	0.7 %	3.0%		
Other (income)/deductions—net	2,116	1,416	3,794	49	(63)
Income from continuing operations before provision/ (benefit) for taxes on income	11,885	12,305	8,351	(3)	47
% of revenues	22.2%	23.4 %	15.8%		
Provision/(benefit) for taxes on income	706	(9,049)	1,123	*	*
Effective tax rate	5.9%	(73.5)%	13.4%		
Income from continuing operations	11,179	21,353	7,229	(48)	*
% of revenues	20.8%	40.6 %	13.7%		
Discontinued operations—net of tax	10	2	17	*	(87)
Net income before allocation to noncontrolling interests	11,188	21,355	7,246	(48)	*
% of revenues	20.9%	40.6 %	13.7%		
Less: Net income attributable to noncontrolling interests	36	47	31	(24)	54
Net income attributable to Pfizer Inc.	$ 11,153	$ 21,308	$ 7,215	(48)	*
% of revenues	20.8%	40.6 %	13.7%		

Cost of sales: 21%
(Labor, packaging, shipping, quality control, chemicals)

Ballpark:
Cost of drug 'chemicals' relatively small part of COS

Marketing: 27%
R&D: 14%

So - before you invest in, or start, a business in bio/tech/health, run the numbers - what are the basics of the business, and what does the completion look like?

How can we imagine and realize the future?

Just because you want something to come true, doesn't make it come true.

Key: opportunities can fail for many reasons, **Technical** and **Societal**

Today's goal: Examine 2 case studies at the cross section of bioengineering and health.

Case#1 Artemisinin: Low cost & Local production of high value chemicals

Centers for Disease Control and Prevention

CDC 24/7: Saving Lives, Protecting People™

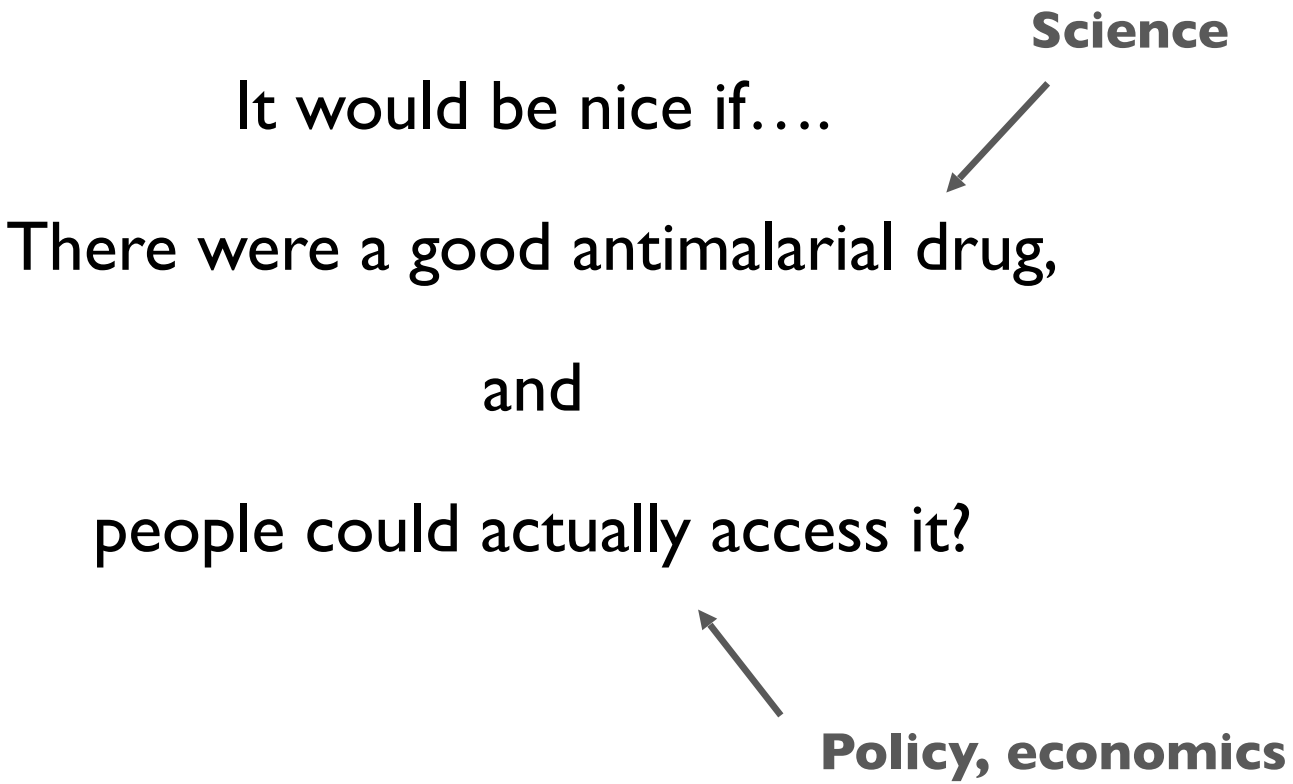
Malaria is one of the most severe public health problems worldwide. A leading cause of death and disease in many developing countries, where young children and pregnant women are the groups most affected.

According to the World Health Organization's World Malaria Report 2013 and the Global Malaria Action Plan

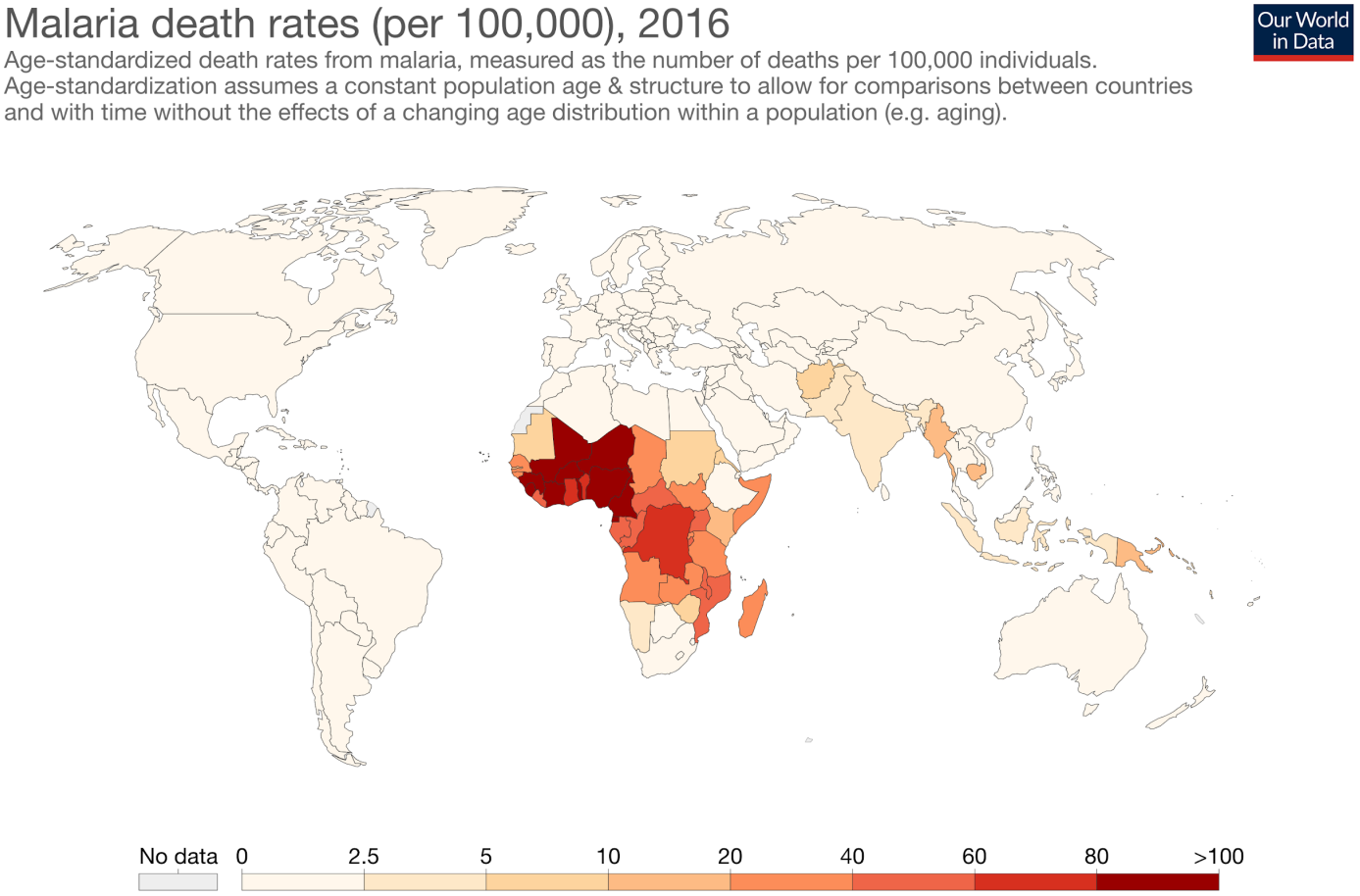
• 3.2 billion people (half the world's population) live in areas at risk of malaria transmission in 106 countries and territories

• In 2012, malaria caused an estimated 207 million clinical episodes, and 627,000 deaths. An estimated 91% of deaths in 2010 were in the African Region.

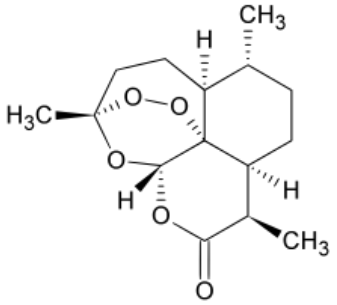
Case-1: Malaria



Case background - Malaria death rates (per 100,000)

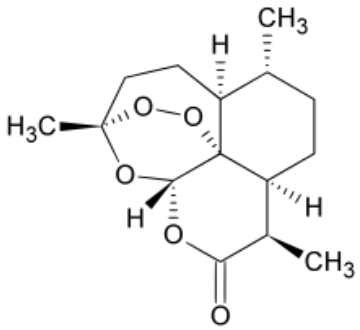


Case background- Artemisinin



1. Artemisinin is isolated from the plant *Artemisia annua* (sweet wormwood) - (Tu Youyou received The Nobel Prize in Physiology or Medicine 2015)
1. Used to treat malaria and parasitic worm infections
1. Advantage: kills parasites faster and all the stages of life cycle
1. Disadvantage: low bioavailability, and high cost
1. Concern: Use of the drug by itself is explicitly discouraged by the WHO. Signs of resistance by malarial parasites

Case background- Artemisinin



amyris

Farming approach:

Grow wormwood, thousands of
Farmers and 20,000 hectares
In Kenya, Tanzania,
Madagascar, Mozambique, India,
Vietnam, and China
Extract compound via solvents (diethylether)
$100-1000 per kg (limited supply)

Alternative approach:

No farming
Double the global supply
Stabilize price to $300/kg.
Prices will drop quickly - tens of dollars per kg.

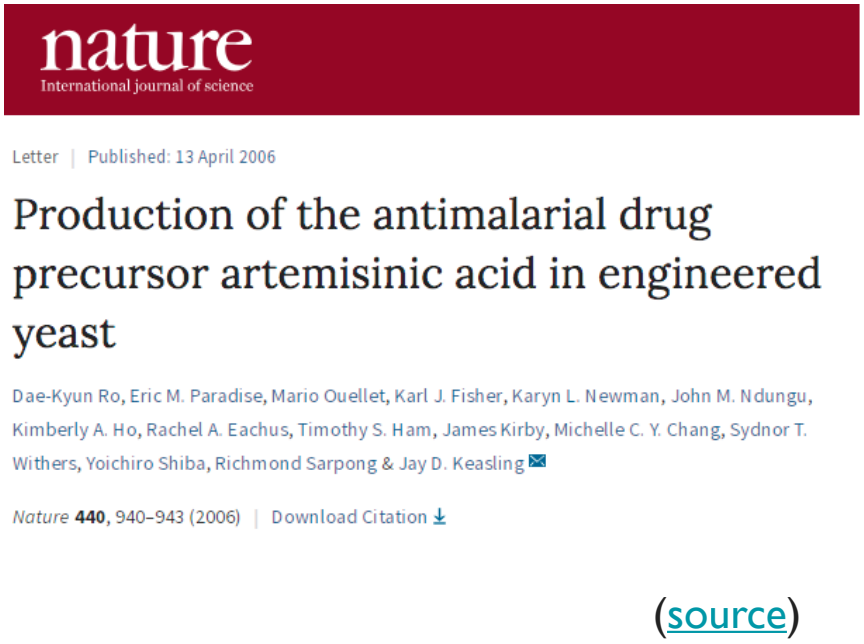
Can be produced anywhere in the world, rapidly

Almost zero land use
No solvents waste

What is the **science** behind the approach?

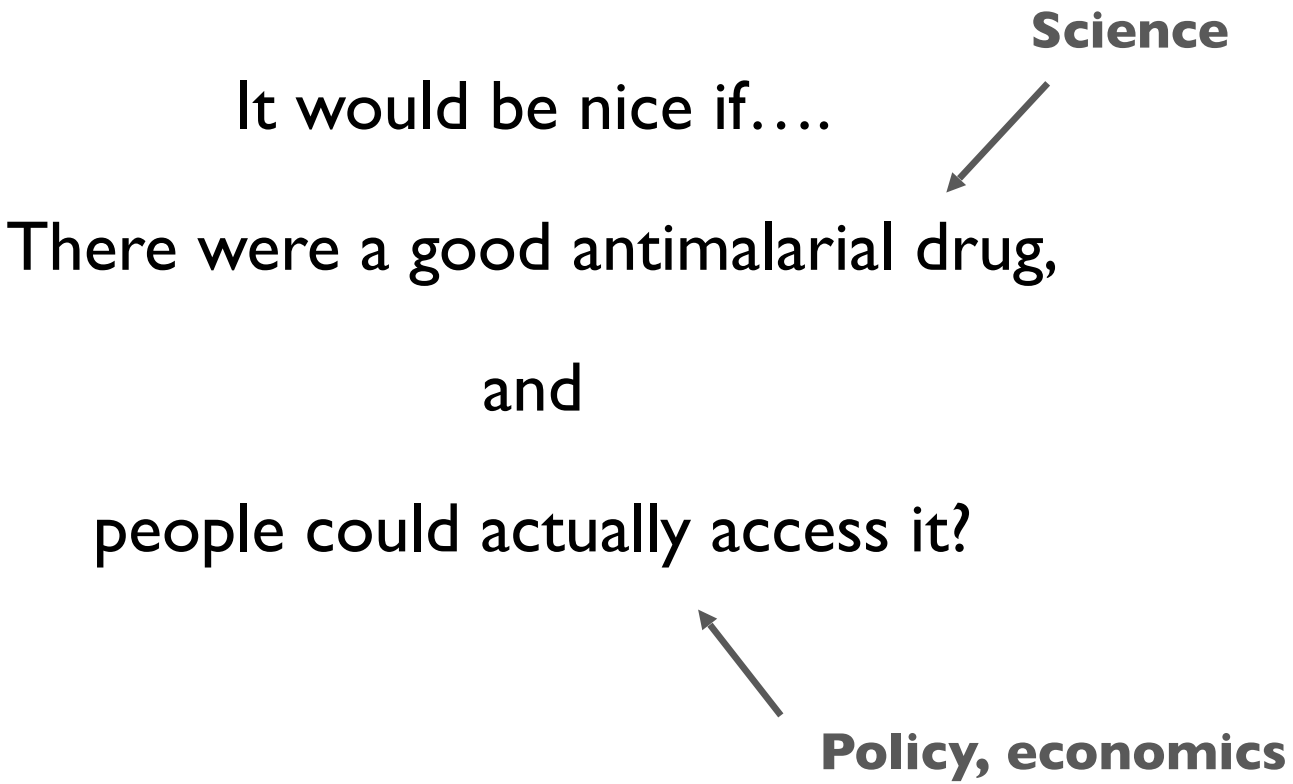
" Here we report the engineering of *Saccharomyces cerevisiae* to produce high titres (up to 100 mg l-1) of artemisinic acid using an engineered mevalonate pathway ...The synthesized artemisinic acid is transported out and retained on the outside of the engineered yeast, meaning that a simple and inexpensive purification process can be used to obtain the desired product.

Although the engineered yeast is already capable of producing artemisinic acid at a significantly higher specific productivity than *A. annua*, yield optimization and industrial scale-up will be required to raise artemisinic acid production to a level high enough to reduce artemisinin combination therapies to significantly below their current prices."



(source)

Case-1: Malaria



What are the **societal** aspects of approach?

Synthetic anti-malarial compound is bad news for artemisia farmers

Artemisinin breakthrough by synthetic biologists threatens to open new front in battle between microbes and people

▲ A farmer harvests sweet wormwood trees in Youyang, rural Chongqing, China, 2006. Photograph: Michael Reynolds/EPA

"In the constant fight between microbes and people, attempts to rein in the malarial parasite have just taken an interesting turn. On Thursday the founder of Amyris Biotech triumphantly announced production of 70m doses of the anti-malarial compound artemisinin. This sounds like good news for poor people but may be a step backwards – the start of a new hi-tech assault on farmers."

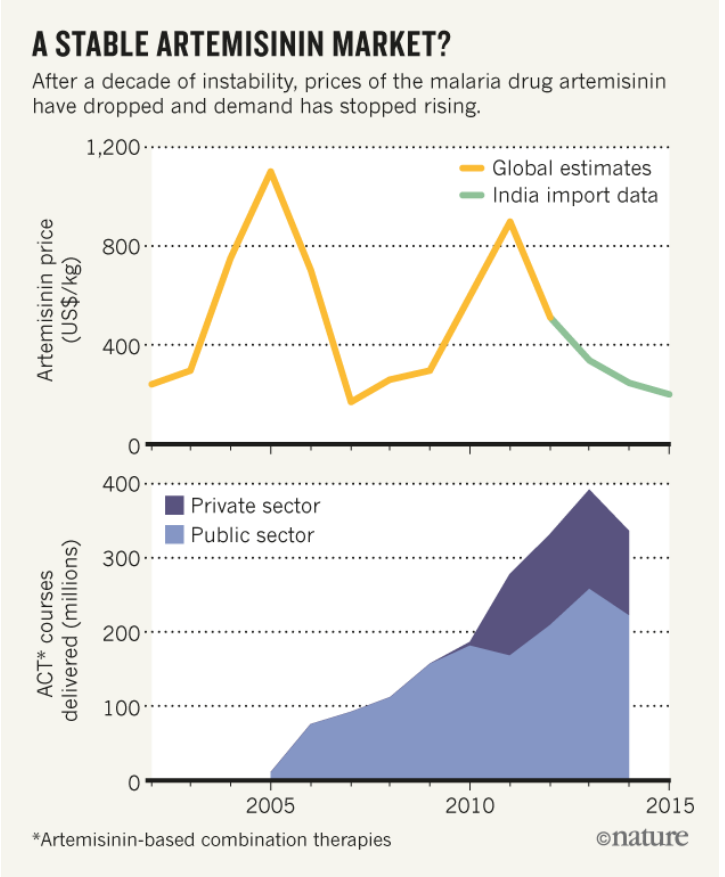
Source

Synthetic biology's first malaria drug meets market resistance (2016)

Commercial use of genetically engineered yeast to make medicine has modest impact.

'That is partly because of a glut in agricultural artemisinin. For the past two years, the naturally derived chemical has sold for less than $250 per kg ..."If that price is already very low and there's a bumper crop, there's no reason to fire up a fermenter," says Jay Keasling of the UC Berkeley, who led the team that first developed the yeast strain… "I'd like to see 'semi-synthetic' artemisinin take over as the dominant form, and some day I think it will," says Keasling. "But we have to be patient." '

Source



Activity-1: Discussion in Groups (2 mins)

In small groups discuss the following:

1. Who are the key stakeholders in this case?
2. Was Amyris successful? Why? What (if anything) went wrong?
3. If you were in charge of Amyris, what would you have done differently?
4. Are there any concerns associated with easy (affordable) access to Artemisinin?

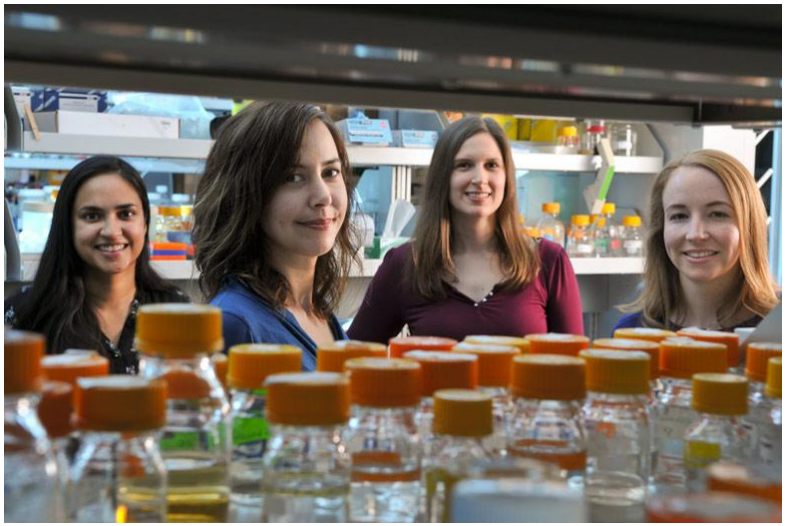
Share back to the entire class

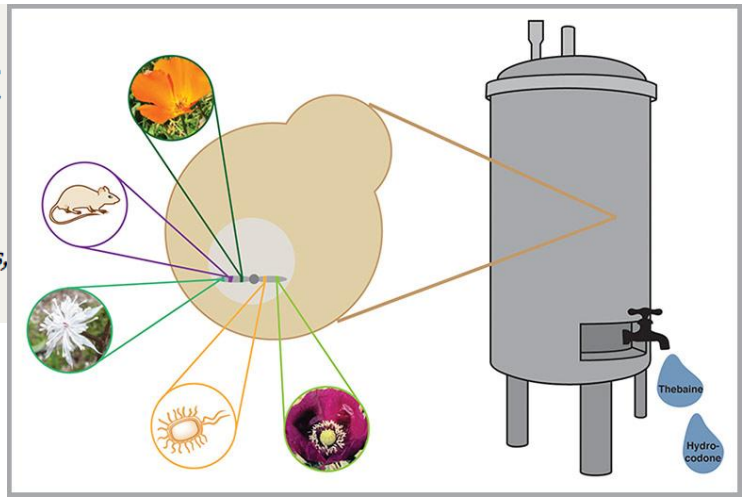
Case#2 Opioids: Low cost & Local production of high value chemicals

AUGUST 13, 2015

Stanford researchers genetically engineer yeast to produce opioids

It typically takes a year to produce hydrocodone from plants, but Christina Smolke and colleagues have genetically modified yeast to make it in just a few days. The technique could improve access to medicines in impoverished nations, and later be used to develop treatments for other diseases.





(Image credit: Stephanie Galanie, Smolke Lab)

Final Project

Intro. to BioE, Spring 2019

15% of grade

Introduce Bioengineering

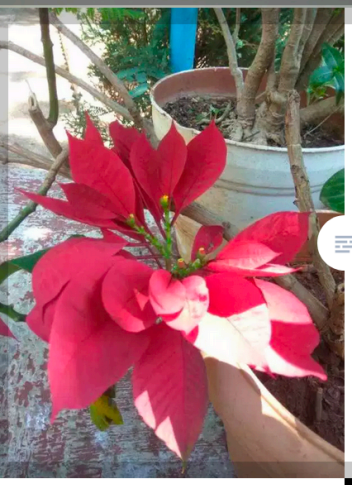
- Topic or aspect of your choosing
- Audience(s) of your choosing
- Method of your choosing*

*Your project output must take the form of some digital artifact that can be shared on a world-readable basis. Video, article, recording, other

https://microcosmos.foldscope.com 67% scope microcosmos

Microcosmos

GETTING STARTED WHAT IS FOLDSCOPE? SHOP TUTORIALS LOGIN REGISTER



Cells of red leaves of Poinsettia

The bright petals of Poinsettias, which look like flowers, are actually the bunch of upper leaves of the plant, called bracts. Poinsettia flowers are small,

READ MORE

One day workshop on Foldscope at Baghmundi village of Purulia, West Bengal, India

READ MORE

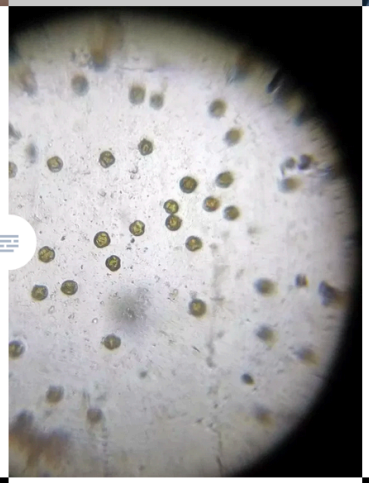
One day with foldscope at the Srijan arts school, Purulia, West Bengal, India

READ MORE

POLLEN OF NEEDLEWOOD TREE

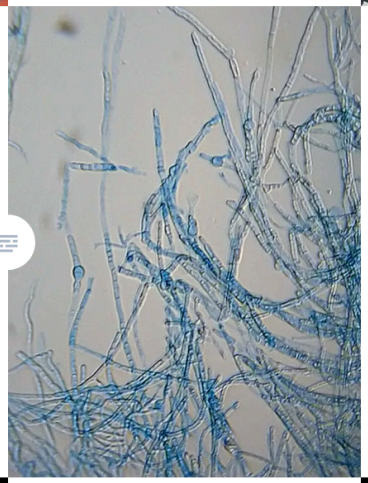
ITS SCIENTIFIC NAME IS SCHIMA WALLICHII , LOCALLY KNOWN IN SIKKIM BY CHILAUNE. This tree is also known for its beautiful flower

READ MORE



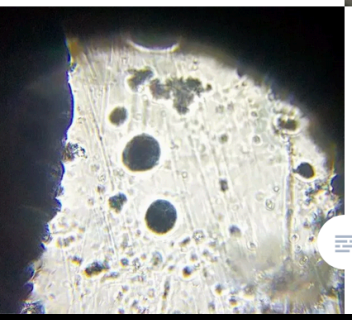
Morphological characterization of Colletotrichum spp. were observed using by foldscope

Mycelium of Colletotrichum spp

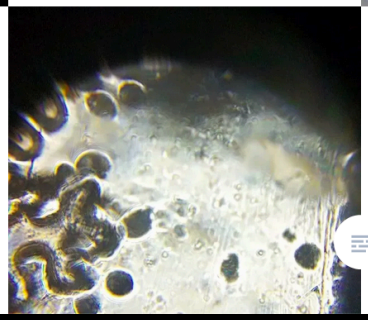


ONE DAY WORKSHOP ON FOLDSCOPE AT ULIDIAH PRIMARY SCHOOL,

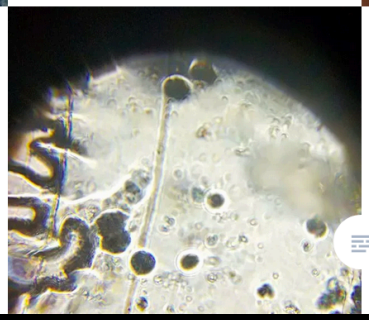
READ MORE



From Hotel Park view from Heema Hospital Area From Raj Bhavan Tinali



Dust Particles from H-Sector area Ganga Market Area From Civil Secretariat

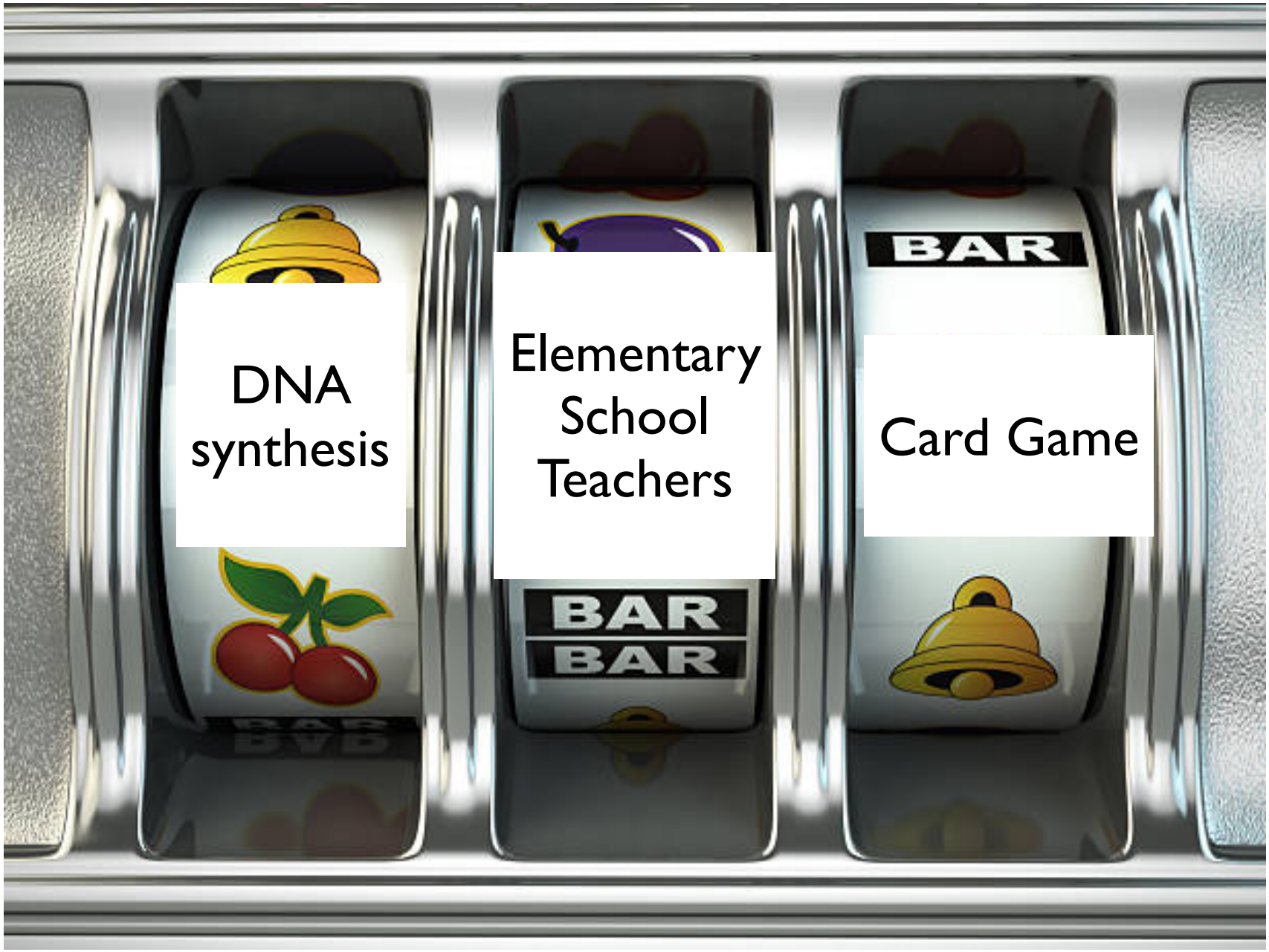


Dust

Dust Particles from Vivek Vihar Area.

Topic/Aspect Audience Method

Topic/Aspect Audience Method



36 points

Teams rule! (6 points)
Brainstorming topic/aspect, audience, method
(starting this Friday; 10 points each)

30 points

Picking topic/aspect, audience, method
(starting Week 6; 10 points each)

30 points

Develop actual project output (NYT editorial, video, etc)
(starting Week 7, 10 points each for different aspects)

4 points

Teammate self assessments

Step 1.

Team building quiz, right now…

Step 2.

Come to class this Friday to assemble into your teams AND learn brainstorming…

Come to class this Friday to assemble into your teams AND learn brainstorming…

CLASS FRIDAY WILL BE HERE, IN 320-105

FRIDAY CLASS WILL BE HERE, IN 320-105

FRIDAY CLASS WILL BE HERE, IN 320-105