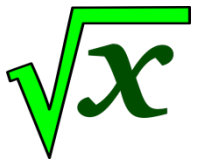
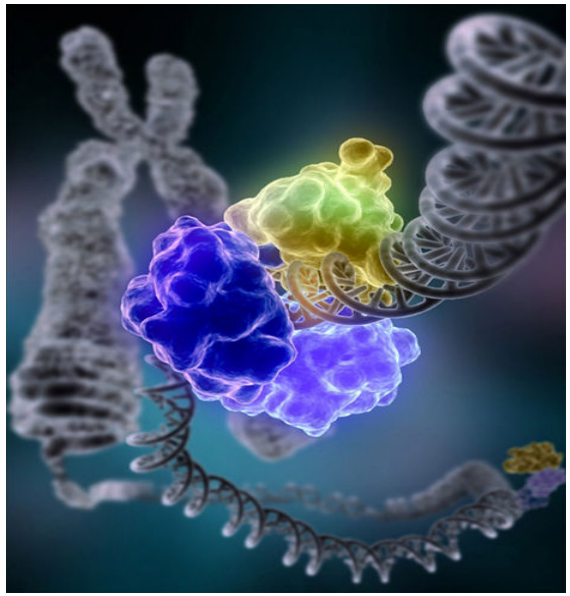
Applications of Evolutionary Insights

How are evolutionary insights applied to aid/ understand humanity?

- "It isn't all math & dinosaurs..."



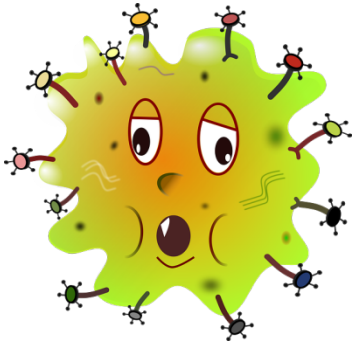
- Quantitative genetics (huge)
- Selection & microbes
- Two "vignettes"



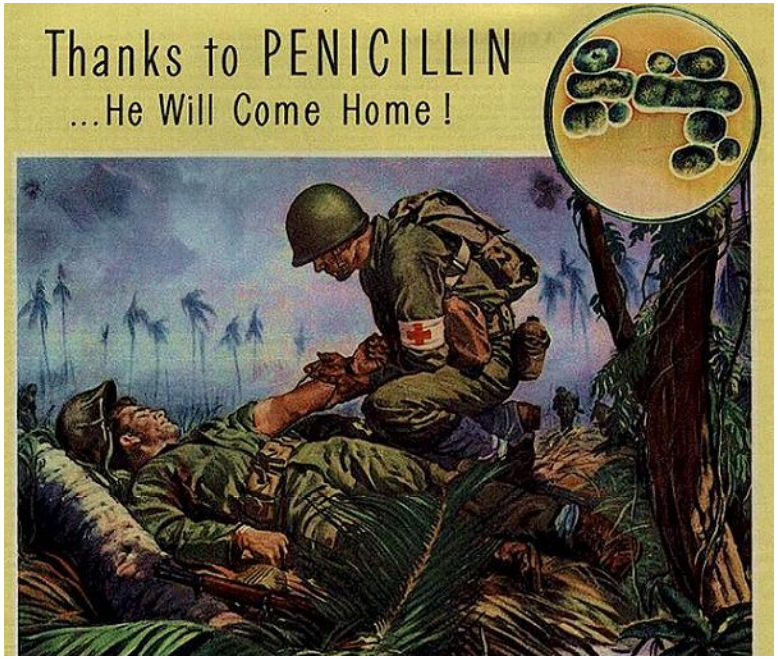
Quantitative genetics

- Similarities between parents/ offspring well known for millennia
  - Some traits "more" heritable than others
- Similarity applied in selective breeding
  - Crops
  - Livestock
  - Pets

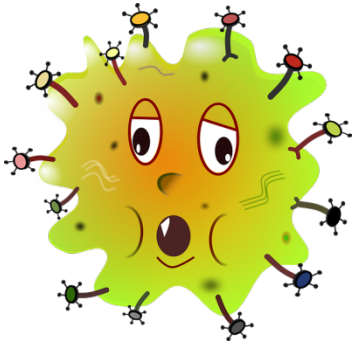
Antibiotic resistance



- Penicillin mass-produced in 1943



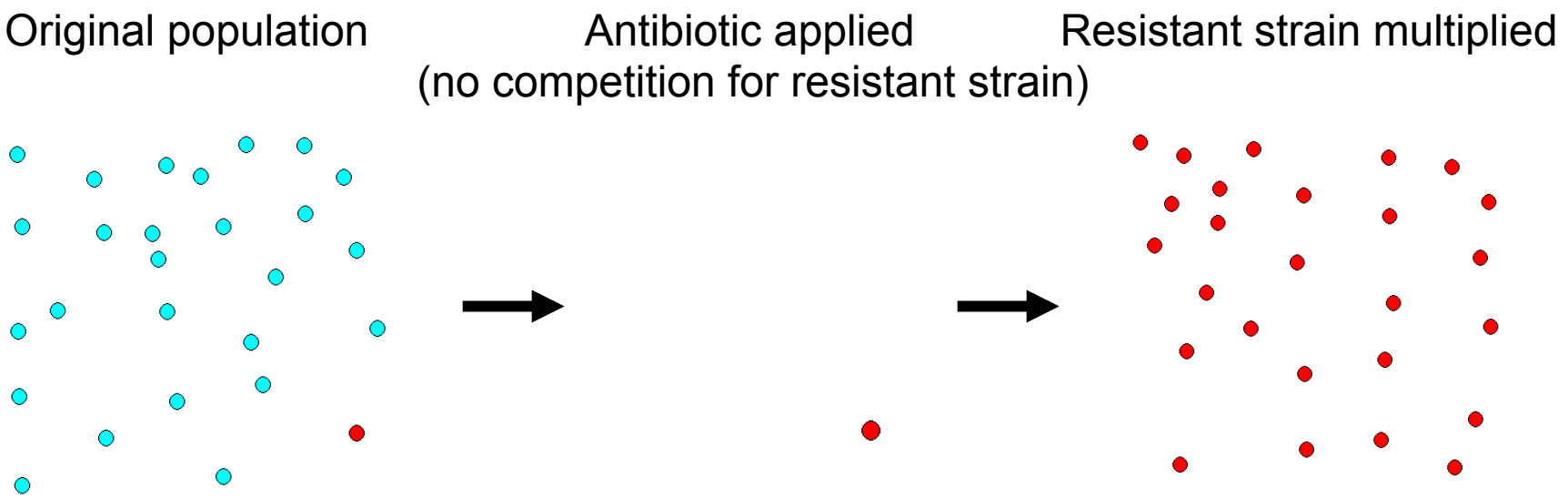
Antibiotic resistance



- Penicillin mass-produced in 1943
- First resistant staph strain found 1947
- 1950: 40% of staph isolates resistant
- 1960: 80% of staph isolates resistant

- How did this happen???

Natural selection for resistance

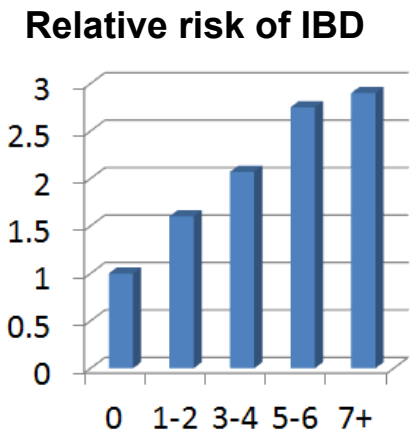


Lesson: antibiotics were (and often still are) overprescribed…

Coadaptation with "good" microbes

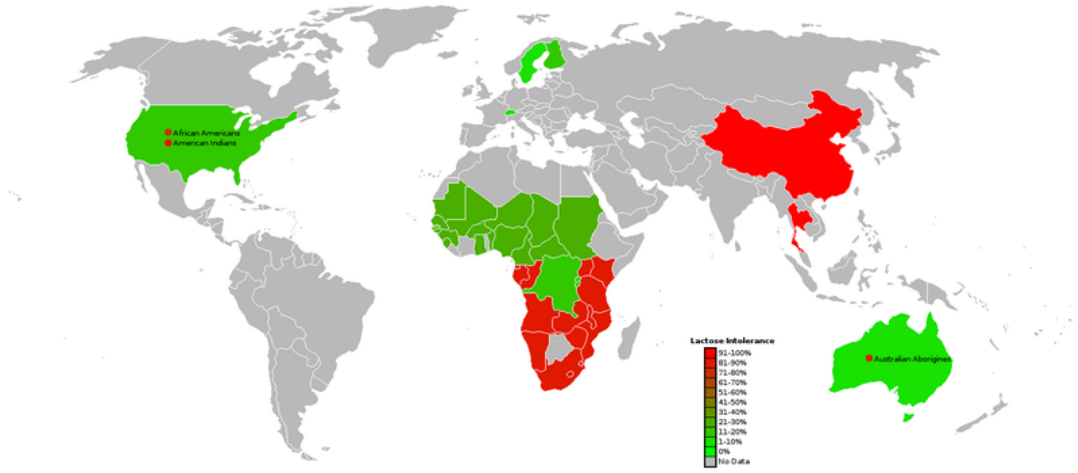
- Humans have co-evolved with many bacteria
  - Synthesize our required vitamin K
  - Help us to resist invading organisms
  - Affects regulation of stomach hormones
- Antibiotics kill "the good stuff" too!

2011 study:



Some vignettes…

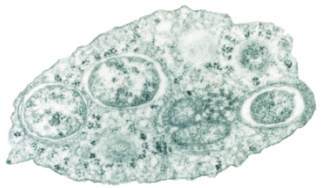
- Control of mosquito spread of dengue using intracellular bacteria
- Understanding human evolution of lactose "tolerance" (lactase persistence)

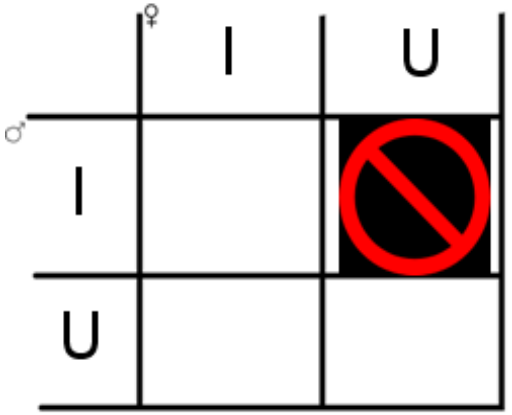


Pest/ disease control

- Dengue fever virus spread by mosquitoes
- Leading cause of child death in SE Asia
- 40% of world at risk of infection
- Some epidemics, including Americas, through 2009
- Control:
  - Kill / avoid mosquitoes?
  - No available vaccine yet

Research on Wolbachia bacteria

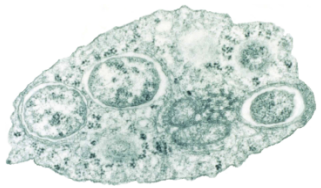


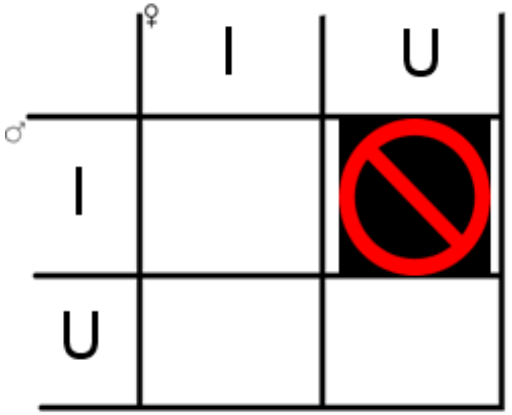


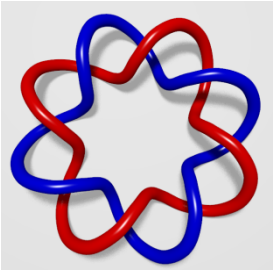
- Intracellular parasite
- Common across insects
- Passed through eggs
- No offspring from mating
  of *infected males* and *uninfected females*
- All other pairings yield offspring

Wolbachia facilitates its spread

- Look at chart
  - Focus on columns
  - Imagine population where some males (I)nfected, some males (U)ninfected
  - For female, is it better to be
    - (I)nfected?
    - (U)ninfected?
    - Which would give more offspring?







Linking the two...

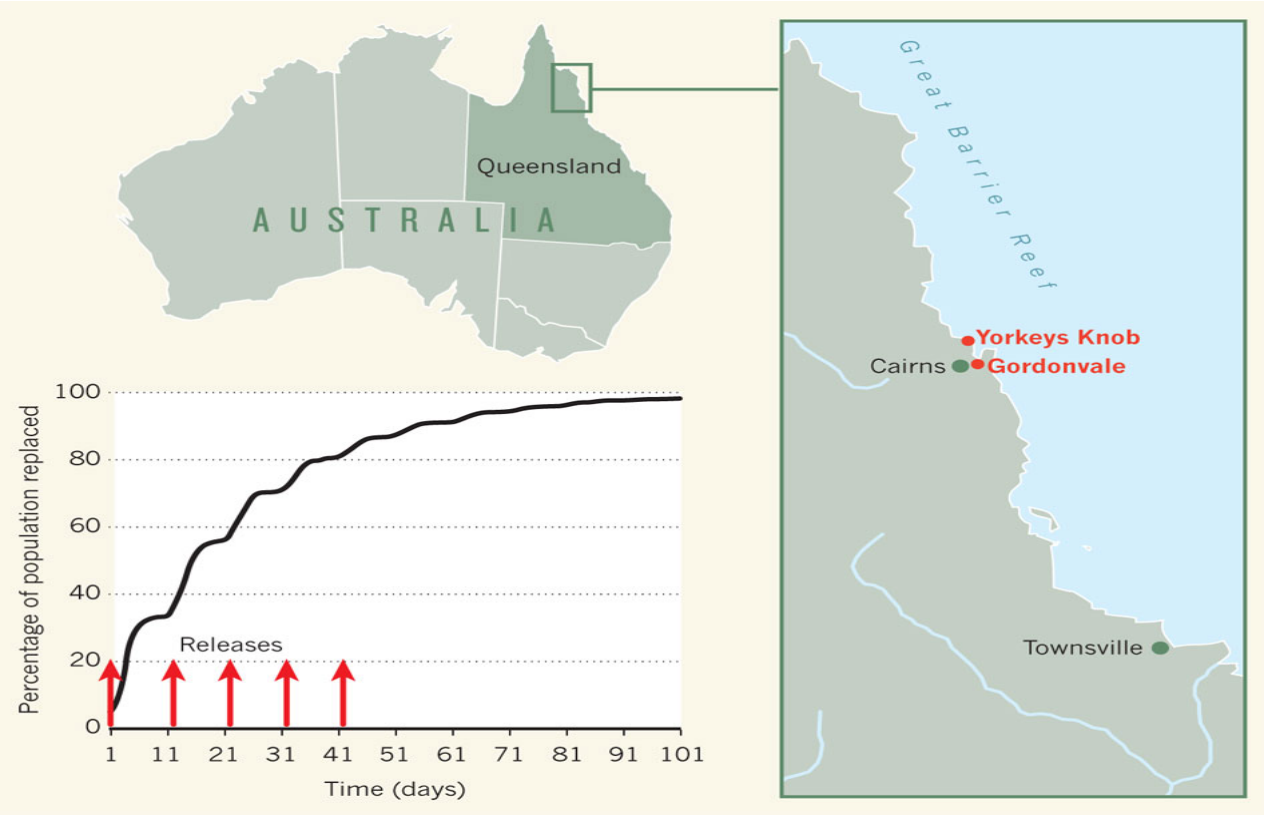
- 2009: Paper published showed could introduce slightly life-shortening Wolbachia into mosquitoes
- 2009: Another study showed Wolbachia directly inhibits viruses from infecting host
  - 2012: Wolbachia infection causes *immune upregulation* and viral inhibition

- Wolbachia infection spreads because of female-advantage

http://www.pnas.org/content/109/1/255.abstract?etoc

Controlled Wolbachia-infected mosquito releases in Australia, 2011

Very rapid spread of Wolbachia infection in local populations...

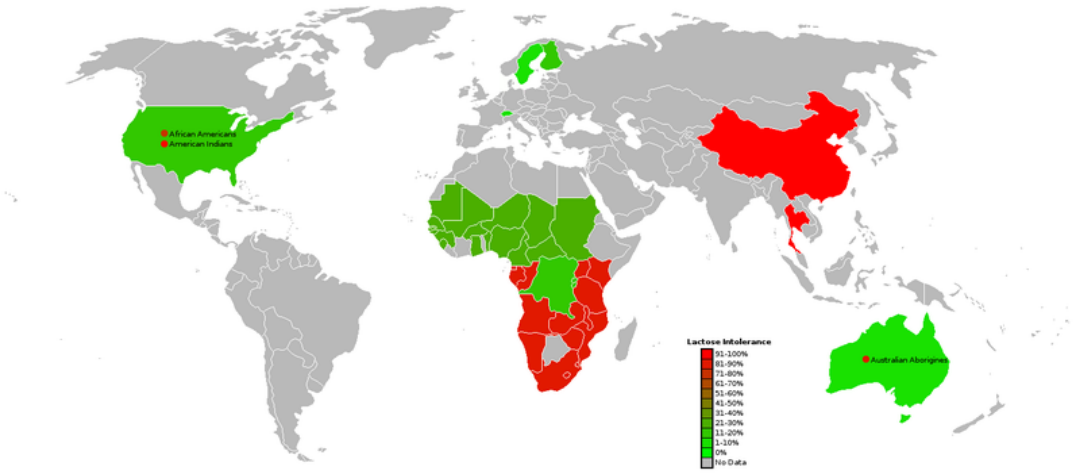


Evolutionary study may reduce/ eliminate dengue!!!

- Leveraging evolution research on Wolbachia
- Outcome may affect 40% of the world's population!!!

Some vignettes…

- Control of mosquito spread of dengue using intracellular bacteria
- **Understanding human evolution of lactose "tolerance" (lactase persistence)**

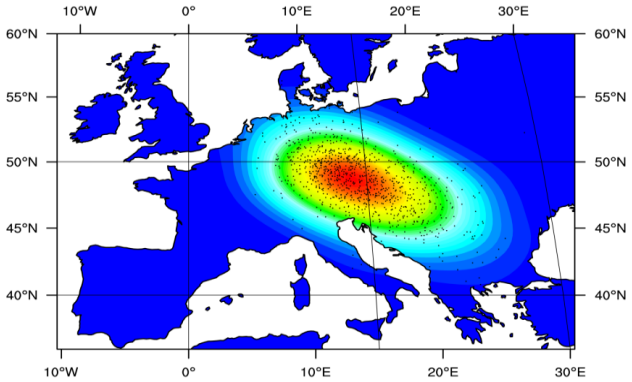


Lactose intolerance

- Extreme, painful gas produced when consume milk products *for people >5 years old*.
- Ancestral condition is **intolerance**!
  - "Mutant" condition is tolerance!
- Today, varies in incidence worldwide
  - 1 % Dutch
  - 12 % European Americans
  - 45 % African Americans
  - 98 % Southeast Asians

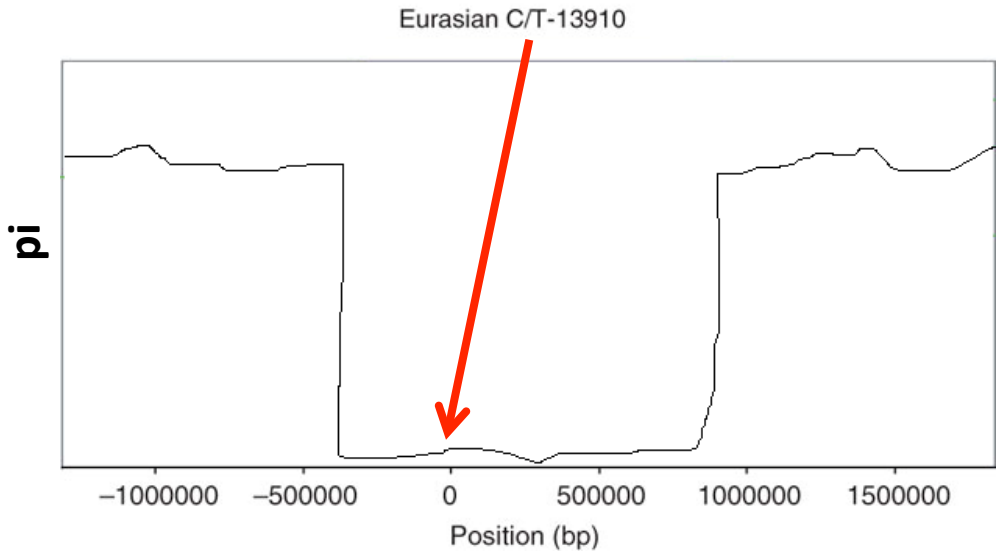
What happened?

- In **EUROPE**, ~7500 years ago, 1-bp mutation occurred allowing production of lactase enzyme in adults (digestion of lactose)
  - Coincides with onset of dairy usage in Europe
  - Selectively advantageous: spread!
- Earlier European fossils do not have this mutation



Selective sweep around this new mutation!

- See long stretch with no nucleotide variation around lactase in individuals having **T** (tolerant) allele…
- **NOT the result of drift...**



Multiple mutations!

- In **AFRICA**, had a *different* 1-bp mutation ~5000 years ago allowing adult lactase production!
  - Found using GWAS
  - See evidence of selective sweep in Africa, too
  - Estimate selective advantage of ~5%
  - Later date coincides with later cattle domestication in East Africa than Europe

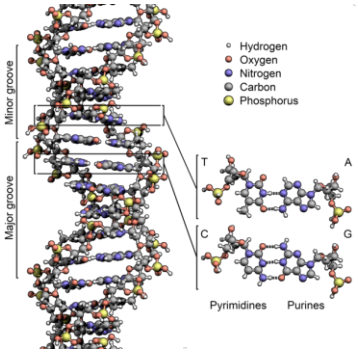
Multiple mutations!

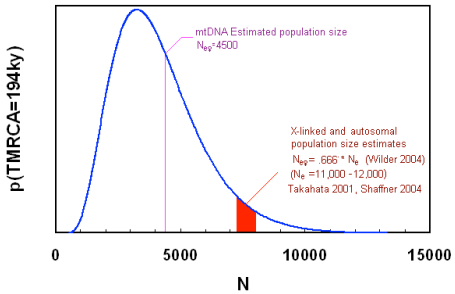
- YET ANOTHER origin in Middle East, effect of two mutations together (epistasis)
  - Evidence that it may have been in response to camel milk consumption
- **Likely others, too…**

Apply what you learned…

Evolutionary genetic studies of lactase persistence in humans

- Associated with "medical" condition
- Genetic mapping done to isolate "cause" alleles
  - Identified multiple, independent origins
- Evolutionary analysis identified *strength* of selection
  - See evidence of hitchhiking
- Coupled genetic data with evolutionary analysis to *date* the new mutation
  - Inferred cause from anthropological data





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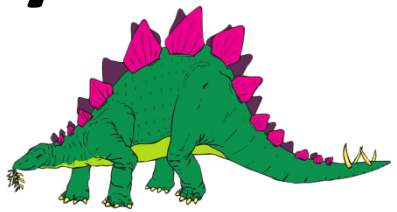

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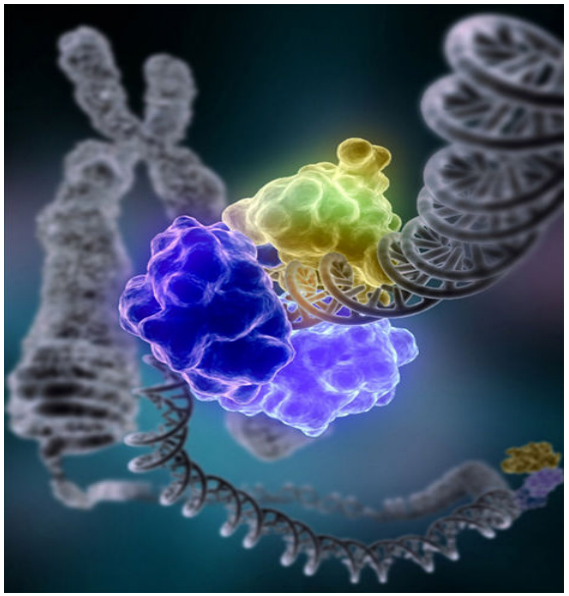

- … and many, many more

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