



The science behind zombies

Luke Hesson, l.hesson@unsw.edu.au

Never Stand Still

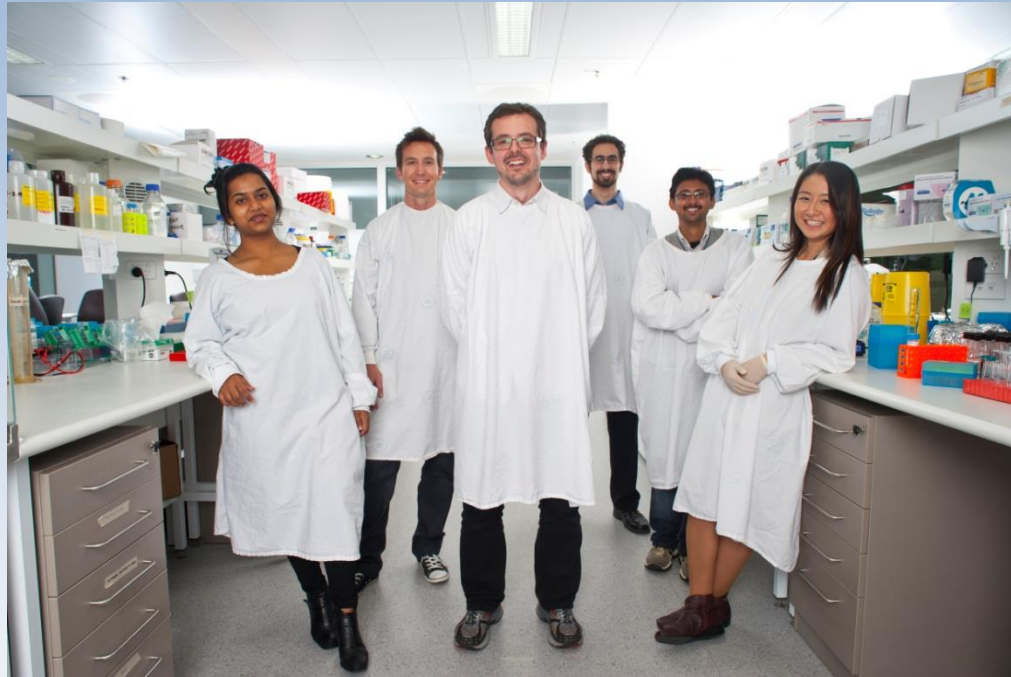
Medicine



ADULT CANCER PROGRAM

Who am I?

What do I do?

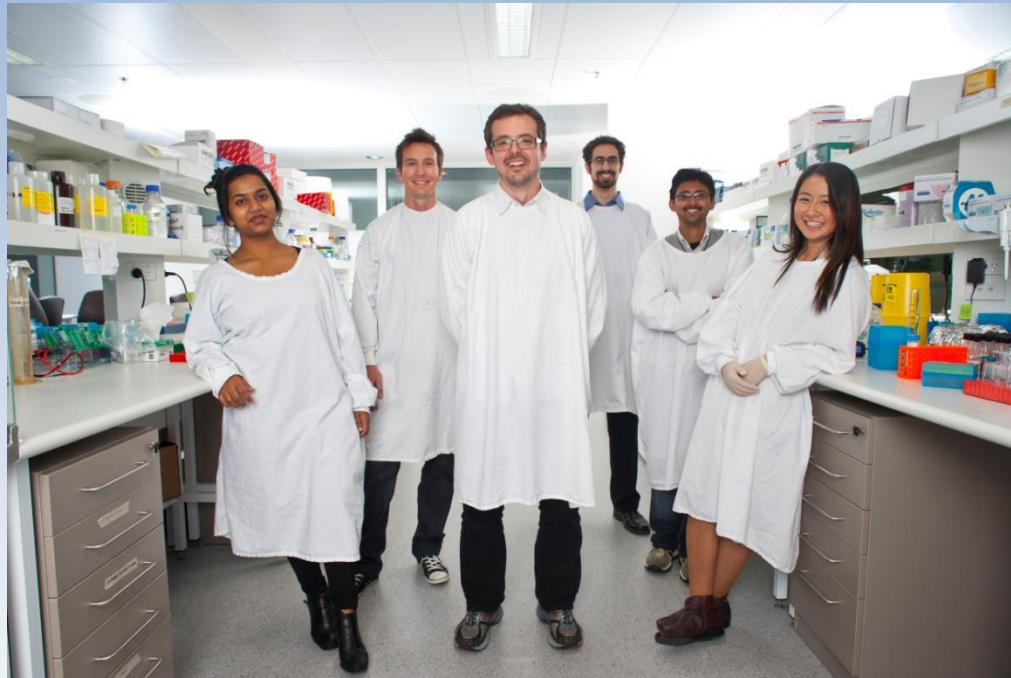


Clinical Geneticist

Cancer Research (colon cancer)

Who am I?

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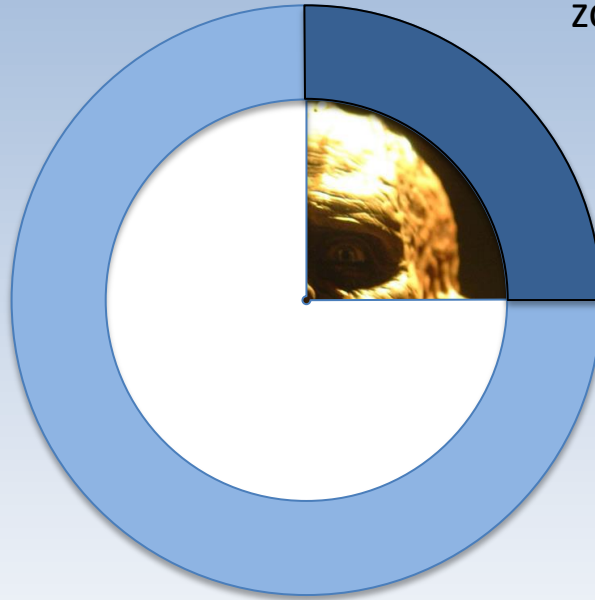


Published over 40 research papers describing the genetics and biology of cancer

Outline



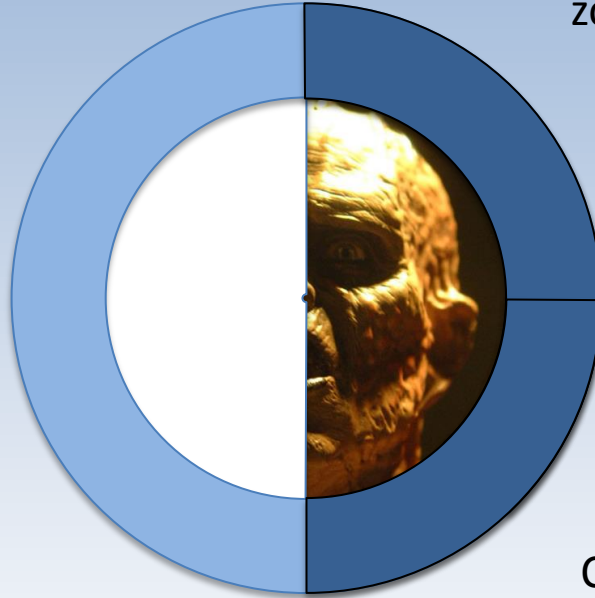
What are
zombies?



Outline

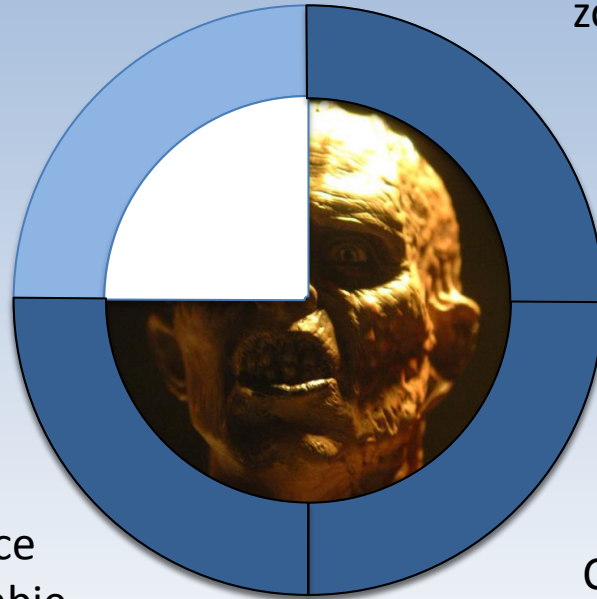


What are
zombies?



Characteristics
of a zombie

Outline



What are
zombies?

The science
behind zombie
characteristics

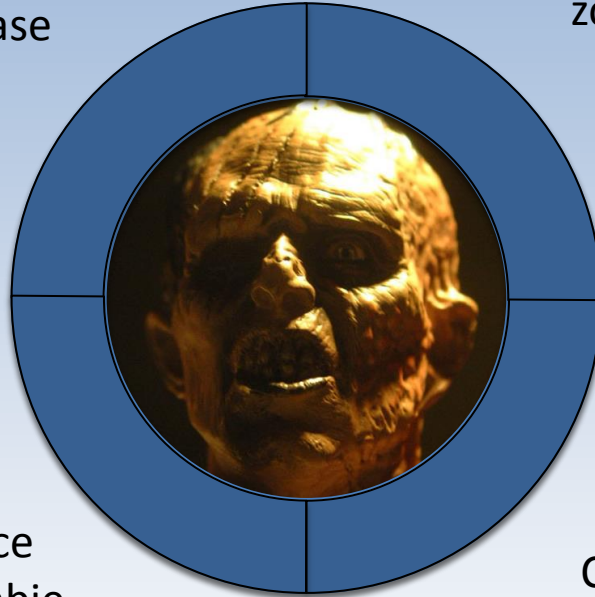
Characteristics
of a zombie

Outline



Precedents in
human disease

What are
zombies?



The science
behind zombie
characteristics

Characteristics
of a zombie

**How can we use a popular concept like zombies
to engage and educate**

What are zombies?



Instinctive

Insatiable hunger

Undead

Impervious to pain

Stupid

Aggressive

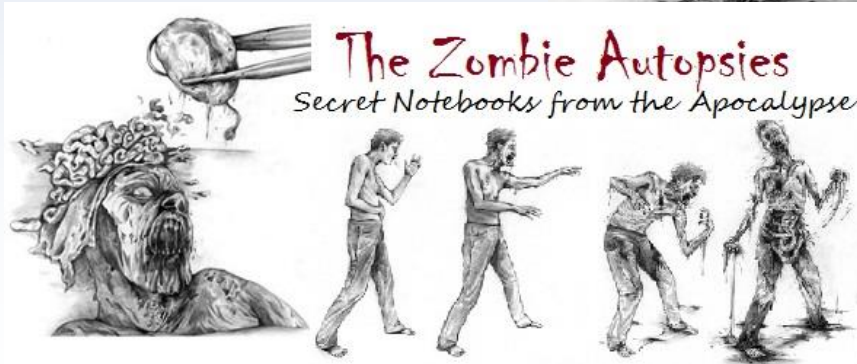
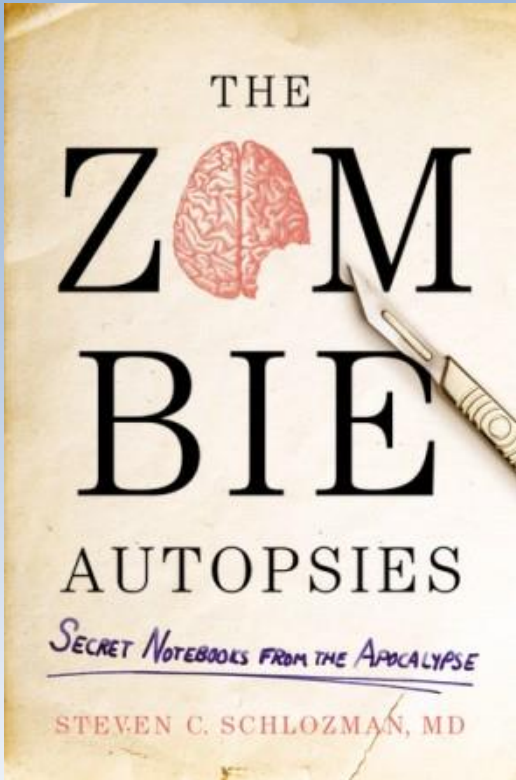
Can only be killed by destroying
the brain

Most of these “symptoms” can be
explained by brain dysfunction

Truncal Ataxia



What are zombies?



Ackermann, H. W.; Gauthier, J. (1991). "The Ways and Nature of the Zombi". [*The Journal of American Folklore* 104 \(414\): 466–494.](#)

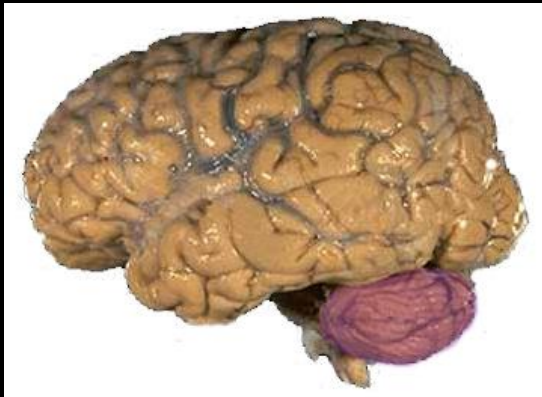


Truncal Ataxia



Stumbling and uncoordinated gait

Coordination is controlled by the cerebellum

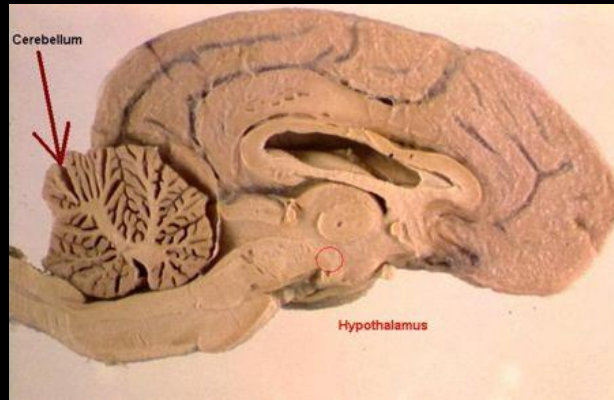


Insatiable hunger



Zombies always have the munchies

The region of the brain that controls hunger (satiety) is called the hypothalamus



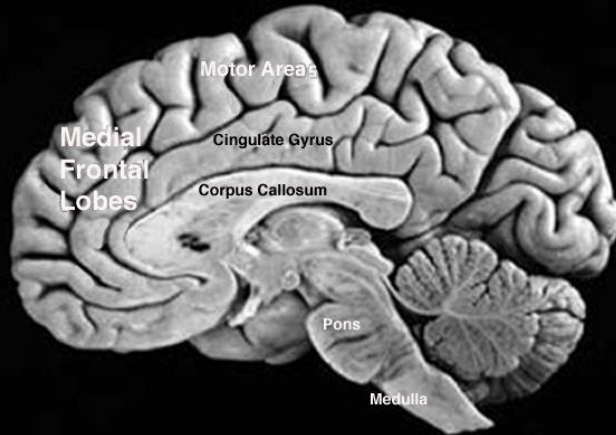
Specifically, the Ventral Medial Hypothalamus is not receiving signals from gut neurons that they're full

Stupid!



Zombies act on instinct

No cognitive function



Cognition is a function of the frontal lobe

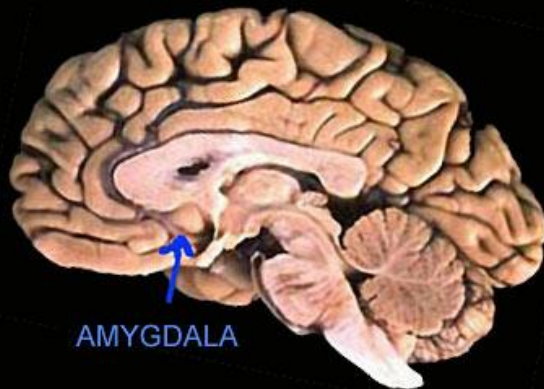


Aggressive



Zombies always seem angry

Aggression is controlled by a region of the brain called the amygdala



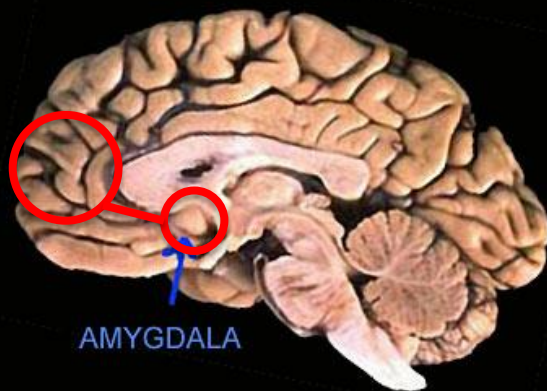
The amygdala is found deep within the brain in the limbic apparatus



Aggressive



In normal brains, the frontal lobe and the amygdala communicate



This is where the conscious decision to fight or run comes from

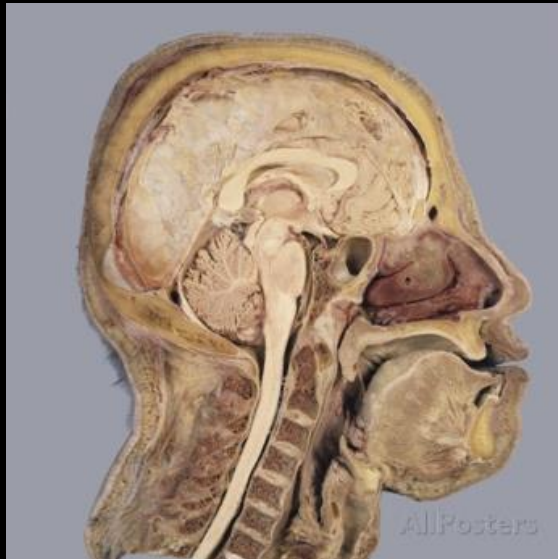
ZOMBIES DON'T HAVE THIS!

Instinctive



Zombies response to loud noises and movement

Their actions are reflexive



Without the brain stem zombies cease to be



Zombiism, or

Ataxic Neurodegenerative Satiety Deficiency Syndrome (ANSD)

Correct medical name for zombiism!

Ataxic

failure of muscular coordination and movement

Neurodegenerative

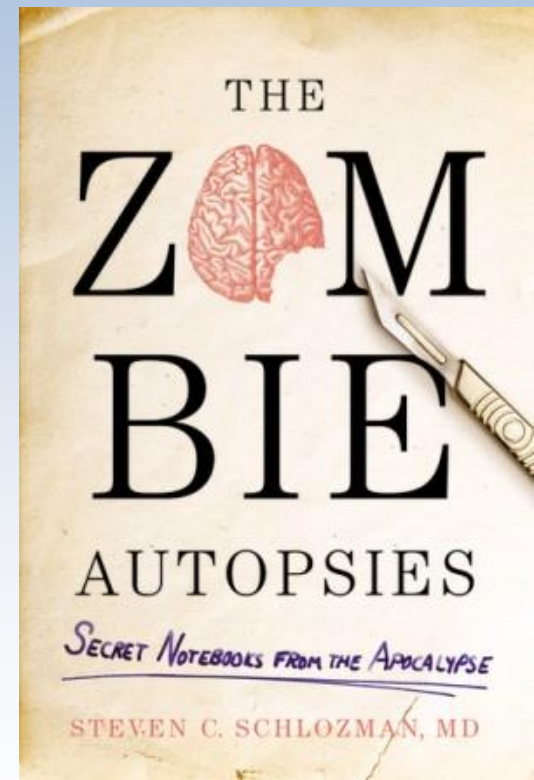
degeneration of neurons in the brain

Satiety

the control of hunger

Syndrome

A group of symptoms that consistently occur together



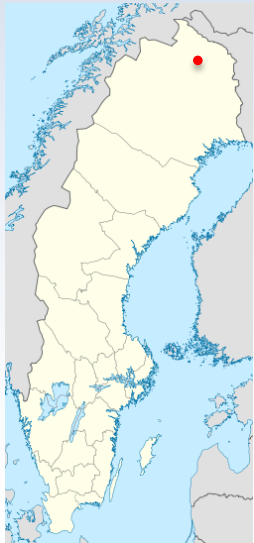
Precedents in Human Disease

Impervious to pain



“Congenital insensitivity to pain”

Caused by mutations to genes involved in nerve function



Vittangi, Sweden,
40/784 inhabitants

Rare inherited conditions in which individuals are unable to perceive pain

Sufferers can bite off parts of their tongue and lips while eating

Some individuals were known to perform in “street theatres” by placing knives through arms and walking on burning coals

Precedents in Human Disease

Aggression



“The warrior gene”

Aggressive behaviour

Mutations to the MAO-A (monoamine oxidase A) gene involved in nerve function

Violence

Impulsivity

Only affects males

Precedents in Human Disease



Ataxia

Alzheimer's Disease

Dementia

Variant Creutzfeldt-Jakob Disease
(vCJD)

Parkinson's Disease

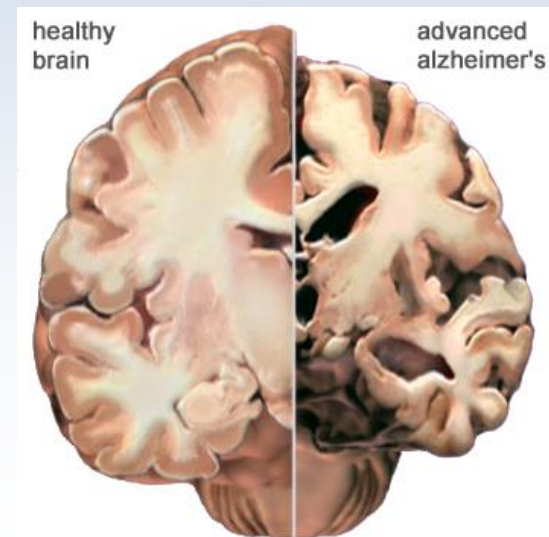
Cerebral Palsy

Multiple sclerosis

Many other rare diseases

Many of these disease damage the
brain stem and cerebellum resulting in
loss of muscle coordination

Affect speech and movement



Precedents in ~~Human Disease~~ chickens

Meet “Mike the headless
chicken”

(a.k.a. Miracle Mike)

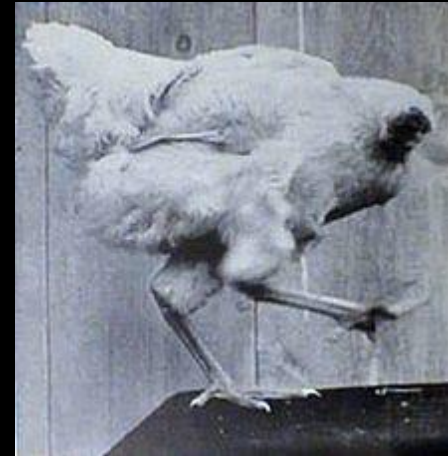
Fruita, Colorado, 1945-1947

Mike survived for 18 months after having his head
chopped off!

The incomplete decapitation left part of the brain
stem

Mike could balance on a perch, walk and
attempted to crow and preen his feathers

This is because the brain stem controls breathing,
heart rate and reflex actions



Precedents in Human Disease



Sleeping sickness

Prevalent in Africa

Caused by the protozoan parasite
Trypanosoma brucei

Transmitted by the tsetse fly.



Early-stage symptoms include:

Headaches

Aching muscles

Itching

Late-stage symptoms include:

Irritable, difficulty concentrating,
slurred speech, lack of appetite,
insomnia at night, narcolepsy during
the day,

Coma, death (50k-70k per year)

Precedents in Human Disease



Rabies

Transmissible through bites from infected animals such as bats



Symptoms:

Full or partial paralysis, mental impairment, agitation and strange behaviour, mania, delirium.

55k deaths annually

Incurable once symptoms are present and 99.99 % fatal

Can take several weeks for symptoms while the virus 'migrates' from peripheral neurons to the CNS

Spoiler:

Although rabies causes aggression and attacks in animals, it doesn't in humans

Precedents in Human Disease



Necrosis

A condition symptomatic of many different disease including:

Cancer

Poisoning

Injury

Infection

Cured by “debridement” or amputation



Disease outbreaks

Ebola virus

First described in 1976

Zaire

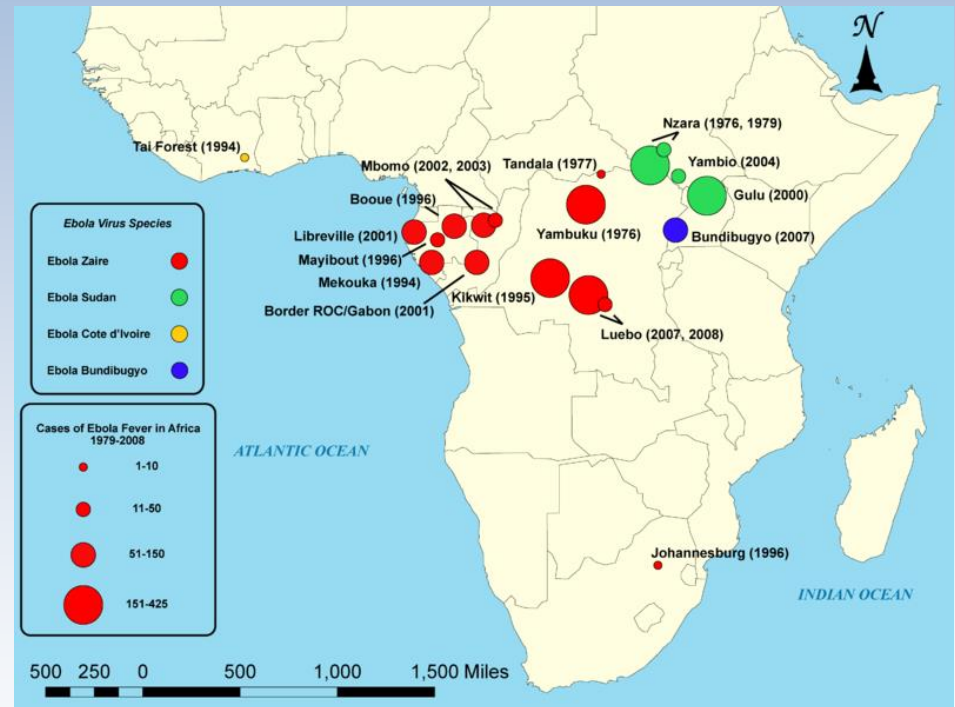
318 cases, 280 deaths, 88 % fatality rate

28 outbreaks to date

> 1640 deaths, mainly in Africa

Ongoing outbreak in Guinea, Sierra Leone and Guinea

- 151 cases, 99 deaths, 66 % fatality rate



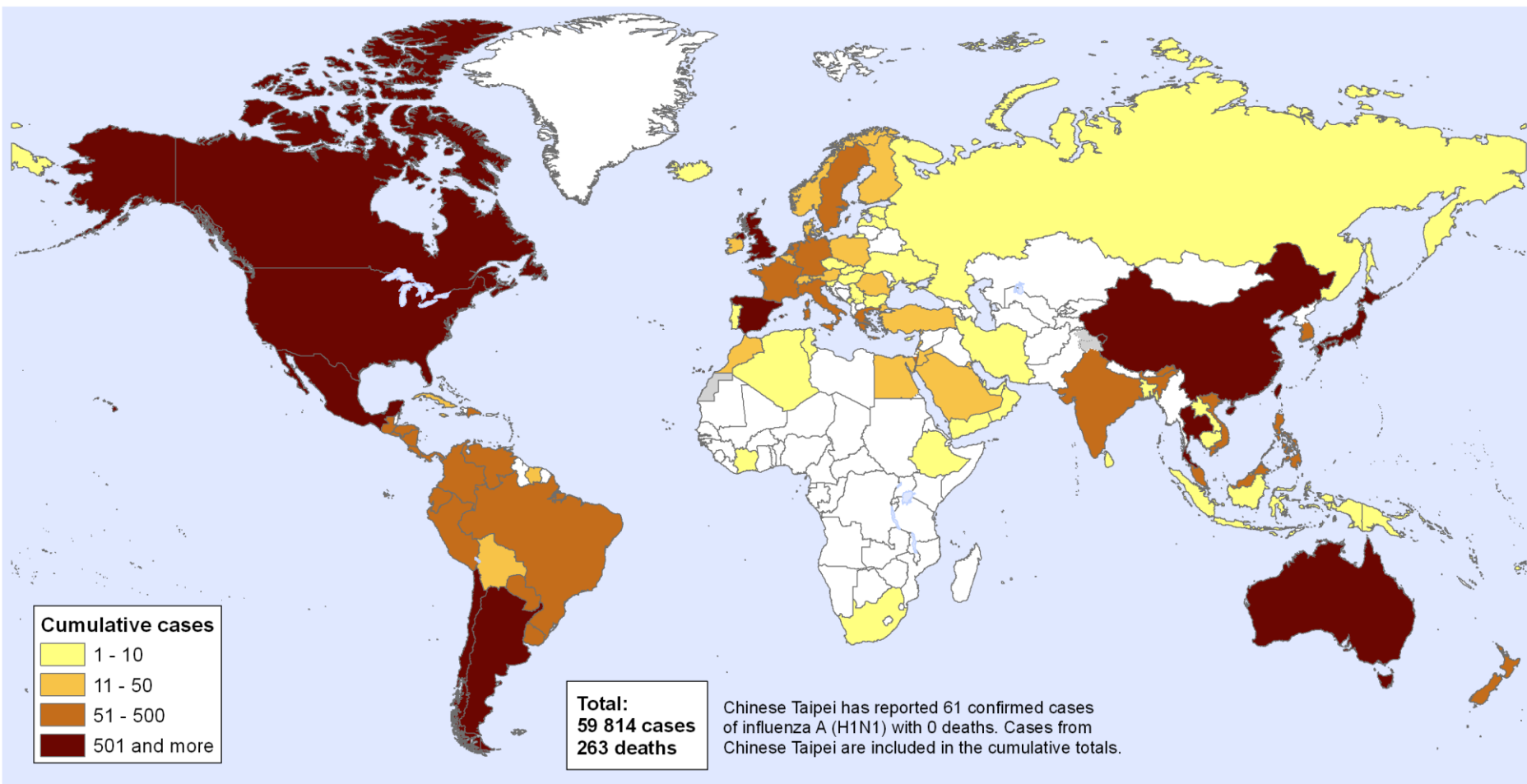
Influenza virus

Statistics from the US

- 5-20% of population get flu each year
- 200,000 hospitalisations/year
- 3,000 to 49,000 deaths each year from flu-related cause
- Influenza and pneumonia = eighth leading cause of death in males in 2009.

New Influenza A (H1N1), Number of laboratory confirmed cases as reported to WHO

Status as of 26 June 2009
06:00 GMT



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

Map produced: 26 June 2009 07:00 GMT

Data Source: World Health Organization
Map Production: Public Health Information
and Geographic Information Systems (GIS)
World Health Organization



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The Search for Better Health

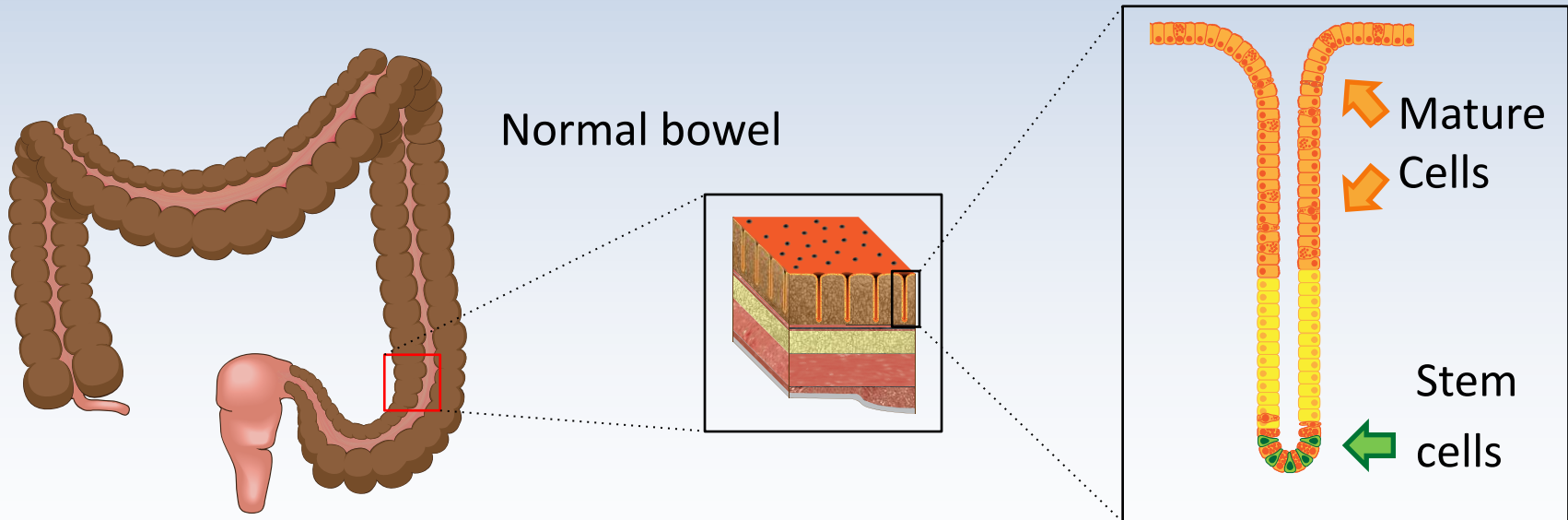
1. What is a healthy organism?

Students learn to:

- discuss the difficulties of defining the terms 'health' and 'disease'
- outline how the function of genes, mitosis, cell differentiation and specialisation assist in the maintenance of health

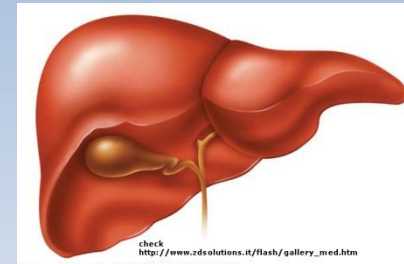
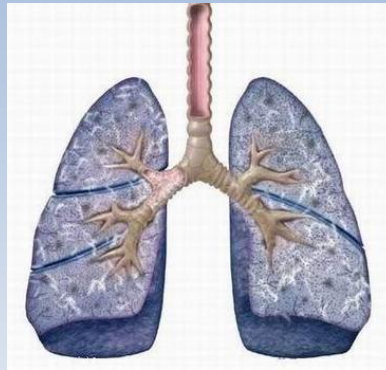
Students:

- use available evidence to analyse the links between gene expression and maintenance and repair of body tissues



These differences between cells are controlled by epigenetics

What is Epigenetics?



- Exactly the same genetic information yet....
- Epigenetics determines how and when genes are switched on or off

What is Epigenetics?

Epigenetics controls the way cells read our DNA

THERE EXIST SEVERAL DEFINITIONS OF EPIGENETICS AND AS A RESULT THERE ARE DISAGREEMENTS AS TO WHAT EPIGENETICS SHOULD MEAN. EPIGENETIC CHANGES CAN MODIFY THE ACTIVATION OF CERTAIN GENES BUT NOT THE SEQUENCE OF DNA. THEREFORE THE TERM EPIGENETICS REFERS TO FUNCTIONALLY RELEVANT MODIFICATIONS TO THE GENOME THAT DO NOT INVOLVE A CHANGE IN THE NUCLEOTIDE SEQUENCE. EXAMPLES OF SUCH MODIFICATIONS ARE DNA METHYLATION AND HISTONE MODIFICATION BOTH OF WHICH SERVE TO REGULATE GENE EXPRESSION WITHOUT ALTERING THE UNDERLYING DNA SEQUENCE. SOMATIC EPIGENETIC INHERITANCE THROUGH EPIGENETIC MODIFICATIONS PARTICULARLY THROUGH DNA METHYLATION AND CHROMATIN REMODELING IS VERY IMPORTANT IN THE DEVELOPMENT OF MULTICELLULAR EUKARYOTIC ORGANISMS. THE GENOME SEQUENCE IS STATIC WITH SOME NOTABLE EXCEPTIONS BUT CELLS DIFFERENTIATE INTO MANY DIFFERENT TYPES WHICH PERFORM DIFFERENT FUNCTIONS AND RESPOND DIFFERENTLY TO THE ENVIRONMENT. PUNCTUATION IS HIGHLY IMPORTANT AND CHANGES THE MEANING OF EVERYTHING.

There exist several definitions of epigenetics, and as a result, there are disagreements as to what epigenetics should mean. Epigenetic changes can modify the activation of certain genes, but not the sequence of DNA. Therefore, the term epigenetics refers to functionally relevant modifications to the genome that do not involve a change in the nucleotide sequence. Examples of such modifications are DNA methylation and histone modification, both of which serve to regulate gene expression without altering the underlying DNA sequence. Somatic epigenetic inheritance through epigenetic modifications, particularly through DNA methylation and chromatin remodeling, is very important in the development of multicellular eukaryotic organisms. The genome sequence is static, with some notable exceptions, but cells differentiate into many different types, which perform different functions, and respond differently to the environment.

What is Epigenetics?

Epigenetics controls the way cells **read** our DNA



What is Epigenetics?

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Punctuation is hugely important and can change the meaning of everything!



What is Epigenetics?

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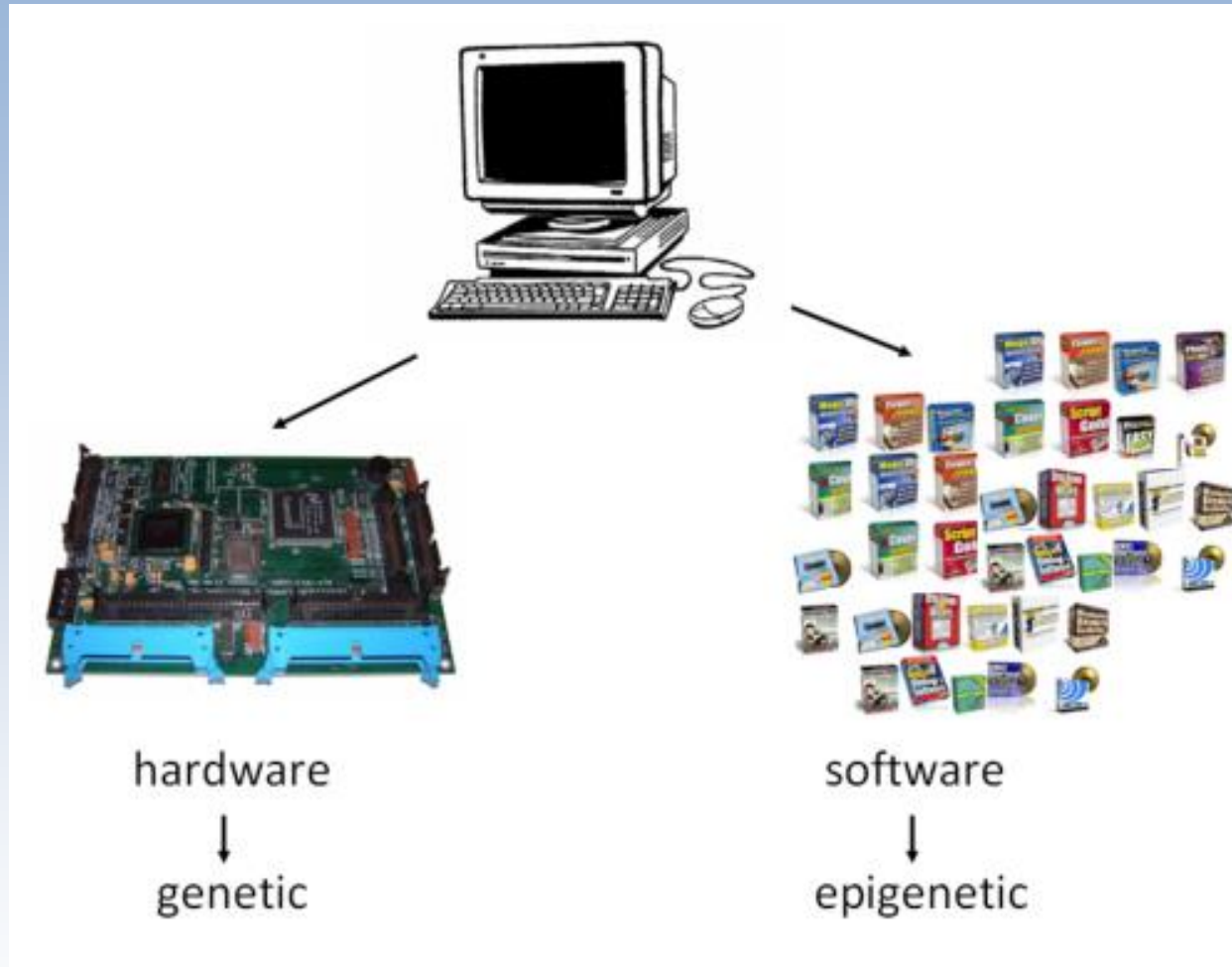


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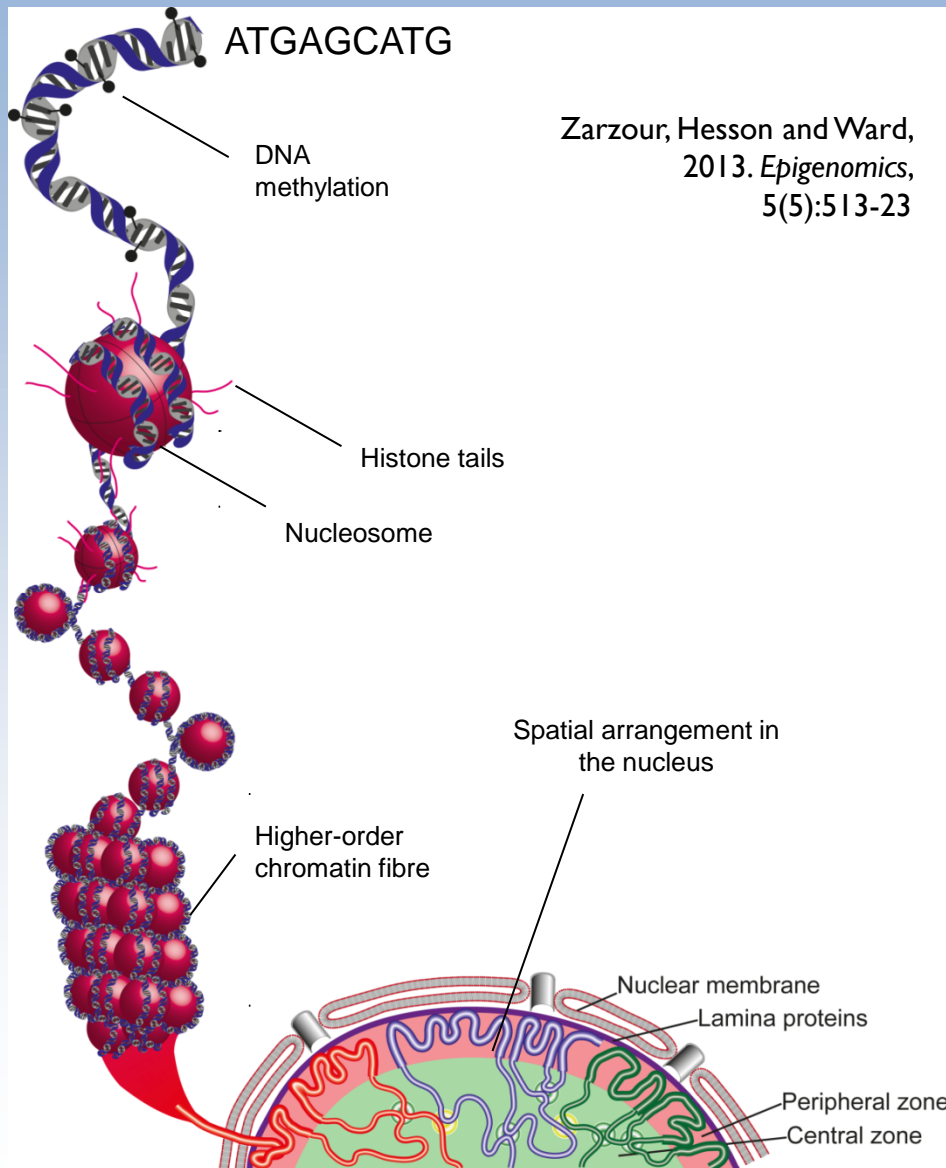


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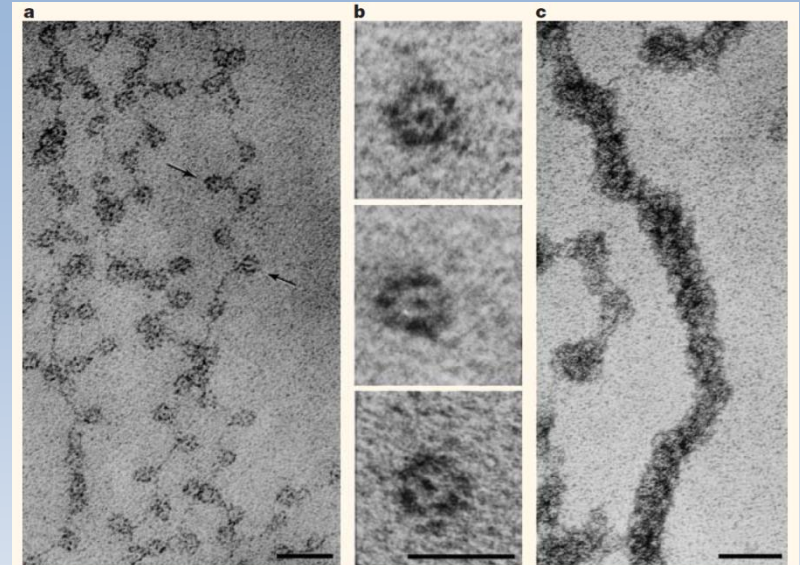


The hardware of a computer is useless without the instructions on how to use it

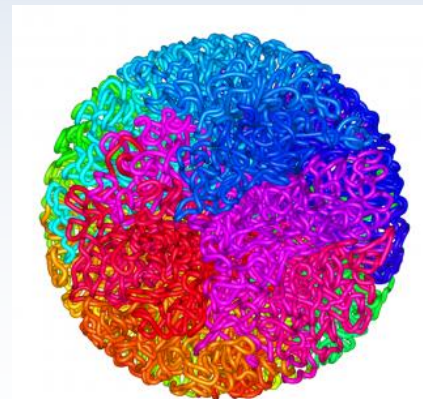
So how does the cell punctuate our DNA?



Zarzour, Hesson and Ward, 2013. *Epigenomics*, 5(5):513-23



Olins and Olins, 2003 *Nat Rev Mol Cell Biol.* 4:809



Lieberman-Aiden *et al.* 2009 *Science* 326:289-293

The Search for Better Health

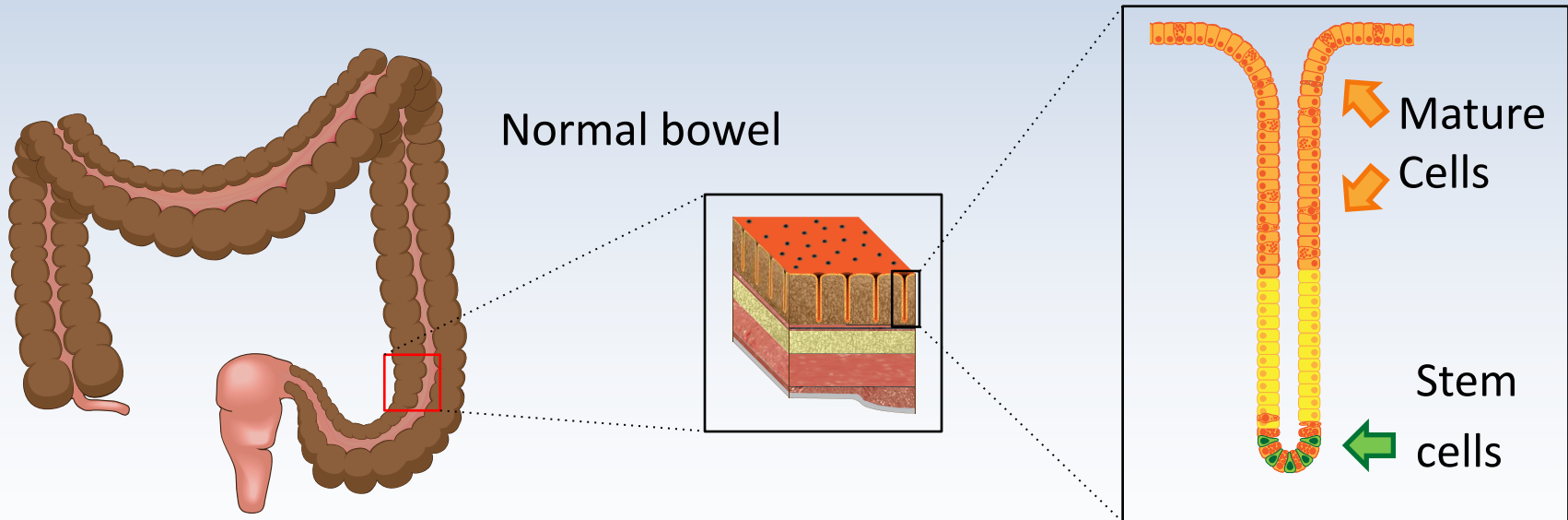
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These differences between cells are controlled by epigenetics

The Search for Better Health

2. Over 3000 years ago the Chinese and Hebrews were advocating cleanliness in food, water and personal hygiene

- distinguish between infectious and non-infectious disease
- explain why cleanliness in food, water and personal hygiene practices assist in control of disease
- identify the conditions under which an organism is described as a pathogen
- identify data sources, plan and choose equipment or resources to perform a first-hand investigation to identify microbes in food or in water
- gather, process and analyse information from secondary sources to describe ways in which drinking water can be treated and use available evidence to explain how these methods reduce the risk of infection from pathogens

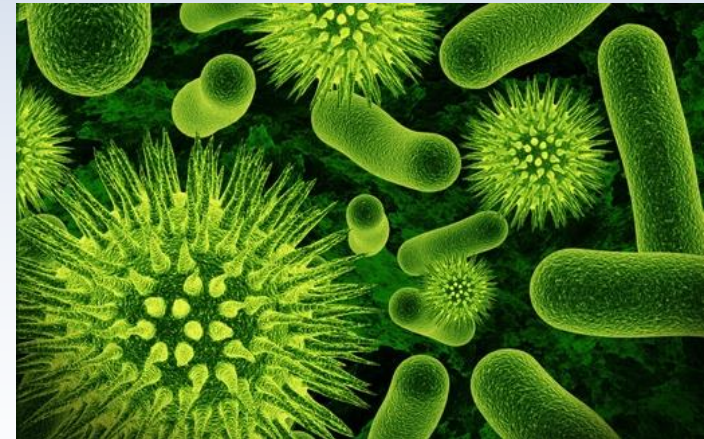
Definitions

Infectious

- An infectious disease is something that can be transmitted.
- Not just humans.
- Usually caused by organisms such as bacteria and viruses – but not always

Pathogen

- Something that can cause disease



The Search for Better Health

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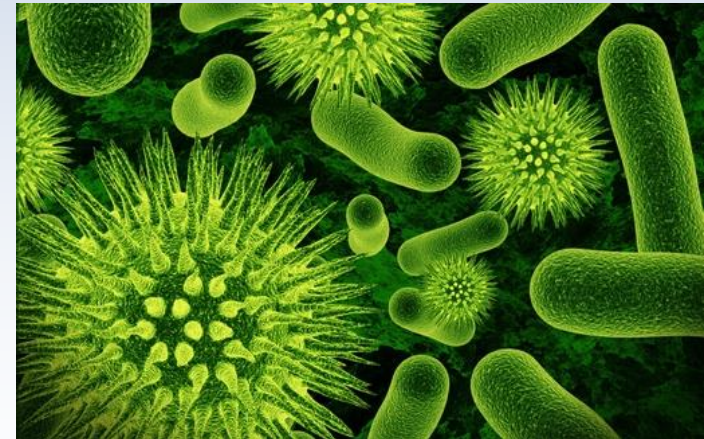
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Pathogen?

Not all bacteria and viruses are pathogens

In each of us, our microbial census exceeds the total number of our own human cells by about 10-fold

Symbiotic relationship
(e.g. they enhance the energy harvest from our diet)



The Search for Better Health

3. During the second half of the nineteenth century, the work of Pasteur and Koch and other scientists stimulated the search for microbes as causes of disease

Students learn to:

- describe the contribution of Pasteur and Koch to our understanding of infectious diseases
- distinguish between:
 - prions
 - viruses
 - bacteria
 - protozoans
 - fungi
 - macro-parasitesand name one example of a disease caused by each type of pathogen
- identify the role of antibiotics in the management of infectious disease

Students:

- perform an investigation to model Pasteur's experiment to identify the role of microbes in decay
- gather and process information to trace the historical development of our understanding of the cause and prevention of malaria
- identify data sources, gather process and analyse information from secondary sources to describe one named infectious disease in terms of its:
 - cause
 - transmission
 - host response
 - major symptoms
 - treatment
 - prevention
 - control
- process information from secondary sources to discuss problems relating to antibiotic resistance

The Search for Better Health

Distinguishing between different infectious agents

Bacteria

- Single cell organisms, motile, prokaryotic
- Cell wall
- Antibiotics effective
- Pneumonia, sepsis, gastric ulcers, bubonic plague/black e

Viruses

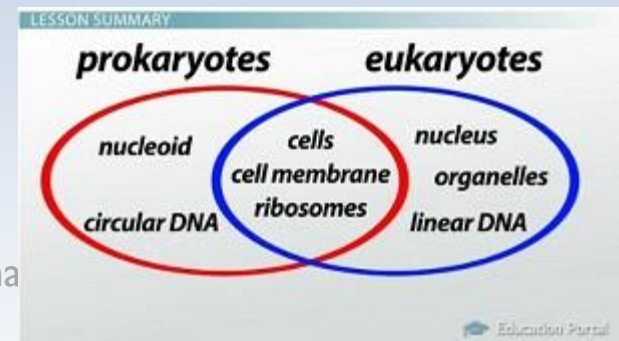
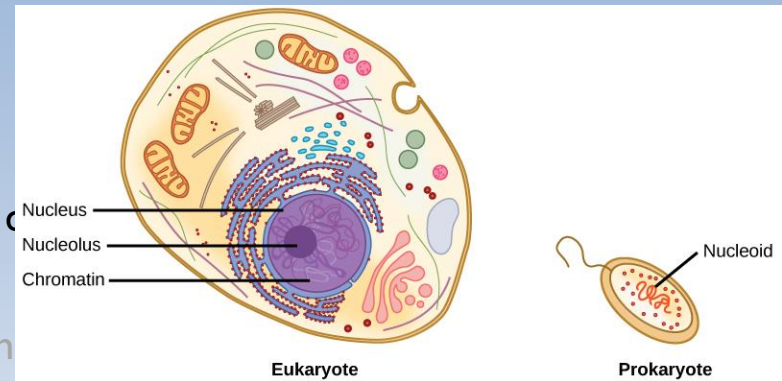
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- Composed of nucleic acid encapsulated in a protein 'capsid'
- Antibiotics ineffective
- Influenza, ebola, rabies, polio,

Protozoans

- Single cell organisms, motile, eukaryotic
- Cause parasitic diseases including malaria (plasmodium), intestinal and African sleeping sickness (Trypanosoma brucei)

Prions

- Proteinacious infection particle
- Infectious agent composed of protein in a misfolded form
- Transmissible spongiform encephalopathies



The Search for Better Health

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Viruses

- Designed to transmit a nucleic acid genome between hosts or host cells
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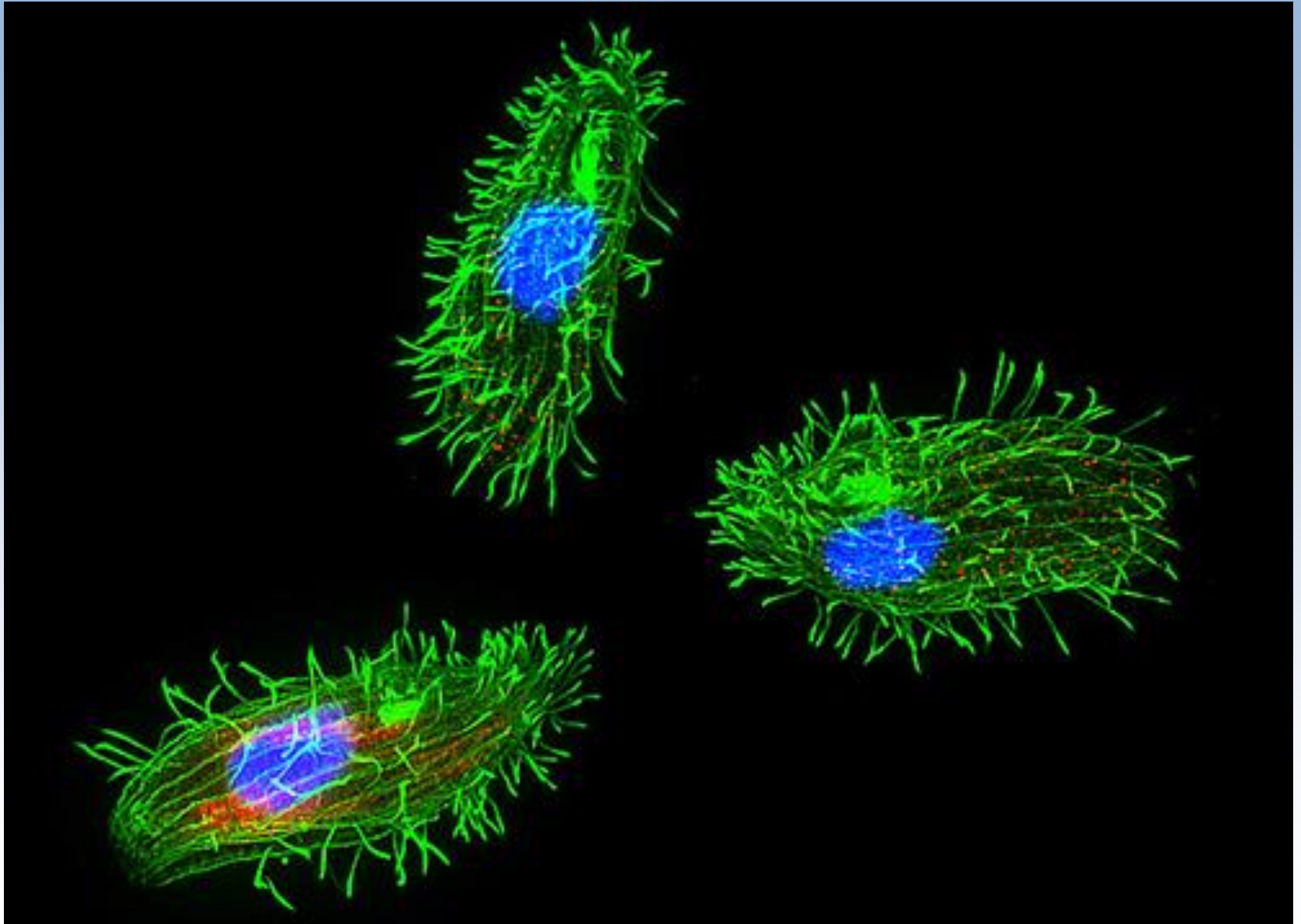
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Protozoa





The Search for Better Health

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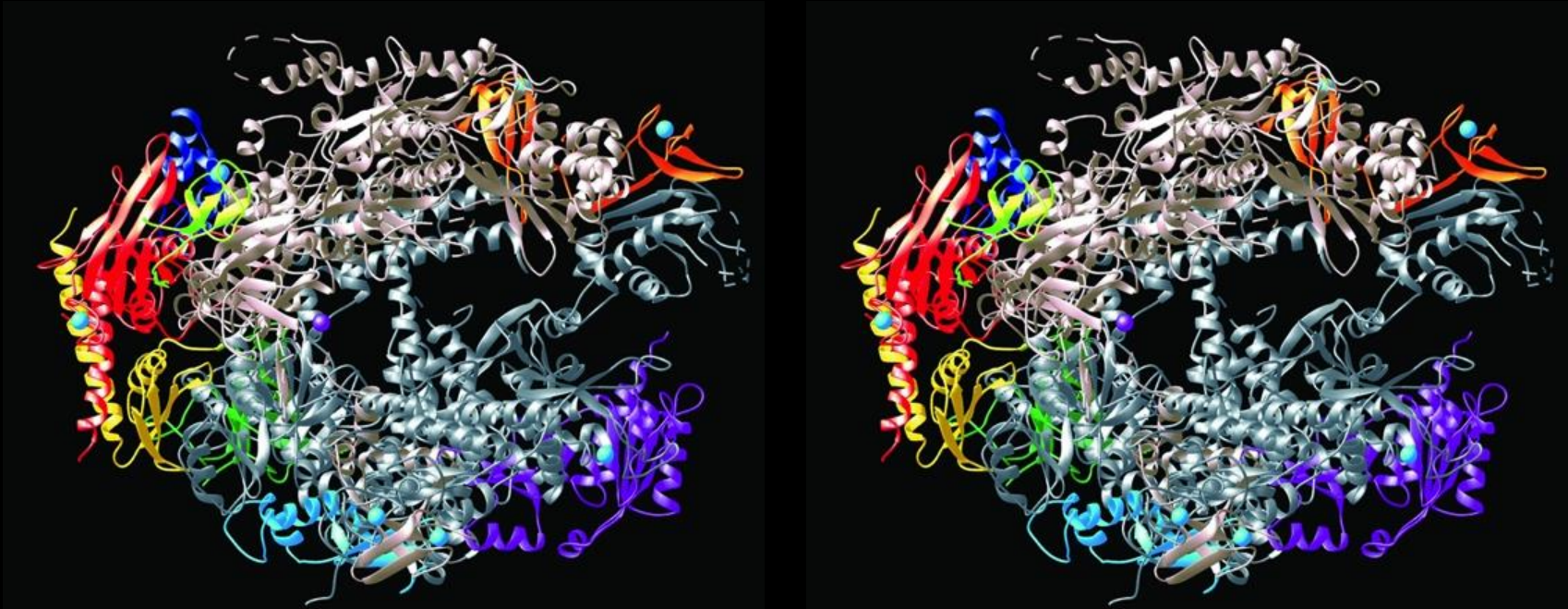
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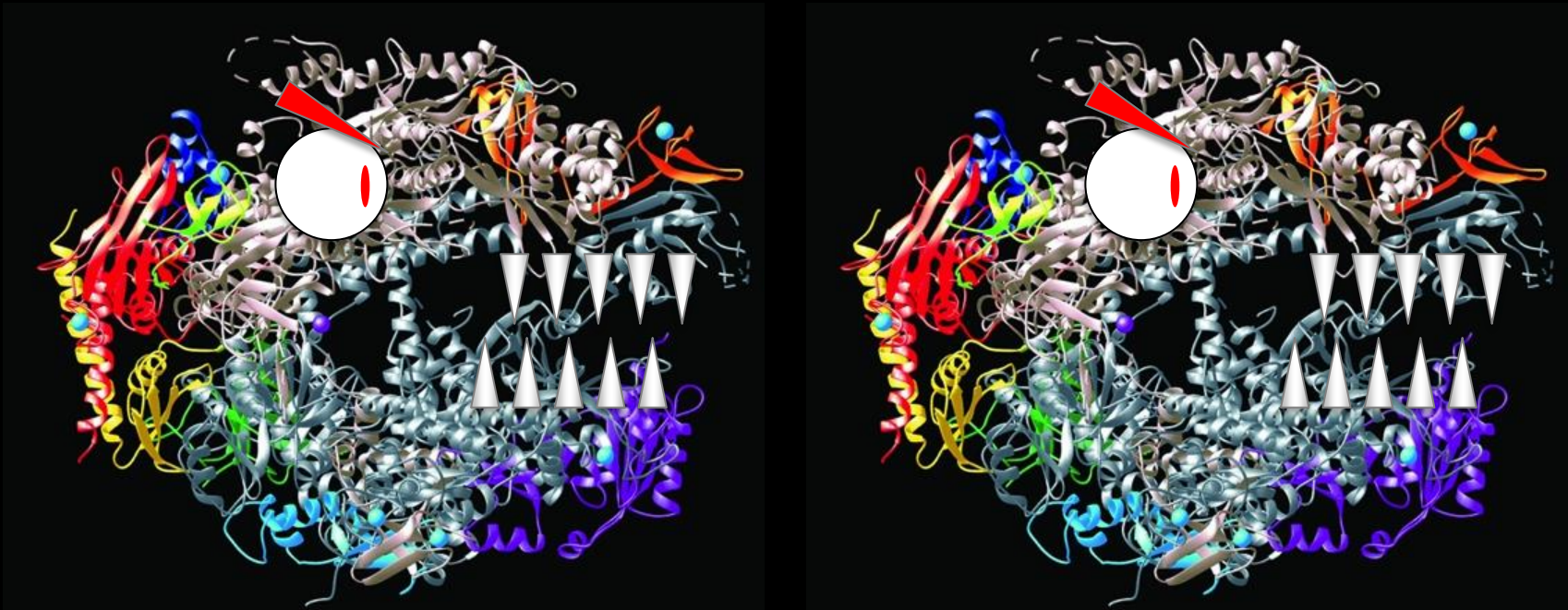
The Search for Better Health

Prions



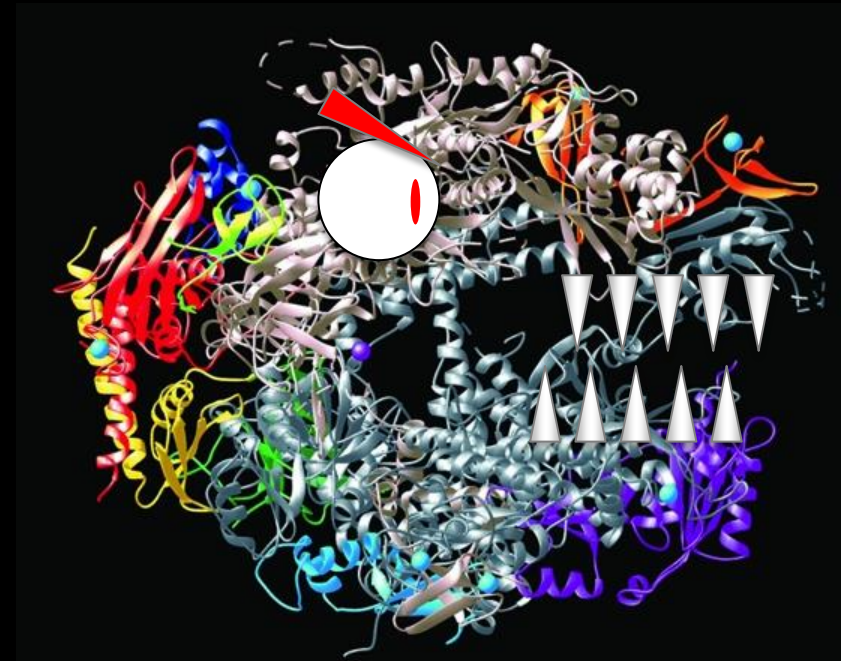
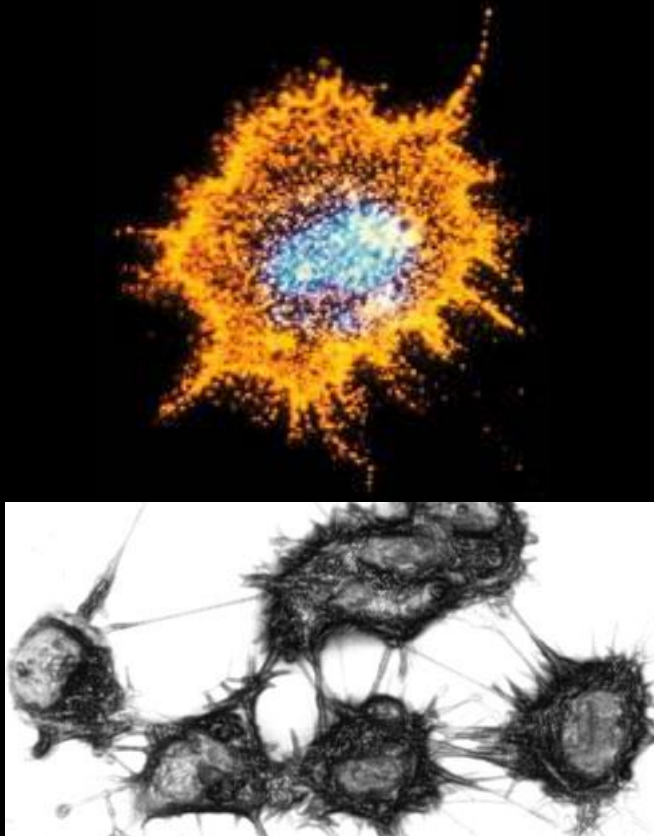
The Search for Better Health

Prions



The Search for Better Health

Prions



- Prions cause the molecular equivalent of a zombie apocalypse