The Body Works?

Part of the UVic Retirees Association (UVRA) Elder Academy Program

Presenters: David Docherty, Ph.D., with Pat Gunton, M.D. and Chris Pengilly, M.D.
We respectfully acknowledge that we are meeting on the traditional territories of the Lekwungen and WSANEC Nations.
Overall approach:

Purpose: To provide some insight into how the body works and what can go wrong so you are able to understand what goes on in your body and communicate more effectively with medical professionals.
Presentations: two parts

1. The anatomy and function of **four** selected systems

2. Things that can go wrong and the **medical interventions** commonly available
The Body Works?

- The Heart (March 5th)
- The Articulations, in particular the knee and hip joints (March 12th)
- The Control Centre (March 19th)
- The Immune System (March 26th)
Presentation: The Brain
(and associated parts!)

David Docherty and Pat Gunton
However, before we start.....

Differences between men’s brains and women’s brains with apologies to Mark Gungor (marriage expert)
Compared the two brains!

Woman’s brain

Man’s brain

Complex network

Boxes
Man’s brain

Organized into boxes that do not touch or connect.

Note: There is no shopping box.
MOMMY, ARE THESE MY BRAINS?

NOT YET, DEAR.
Outline of presentation (first part)

• Neurons and how they communicate
• Organization of the brain and nervous system
• How messages get to their targets and how information is relayed back.
• Brief mention of the Autonomic Nervous System
• How the brain is protected.
• Circulation of blood and CSF in the brain.
The real thing!

The brain

The nerve cells (neurons)

Would you believe 86-100 billion!
The Nervous System

• The nervous system includes all the neural tissue in the body.
A Functional Overview of the Nervous System

- This diagram shows the relationship between the CNS and the PNS and the functions and components of the afferent and efferent divisions.
Histology of Neural Tissue in CNS
The Structure of a Synapse

(a) A chemical synapse
The Structure of a Synapse

Up to 1000 connections!
How neurons communicate

• https://www.youtube.com/watch?v=o9p2ou1lyC0
Neurons can connect with:

1. Synapses with another neuron
2. Neuromuscular junctions
3. Neuroglandular junctions
Pre Central Gyrus (Motor Cortex)
anatomical and functional landmarks
A Megasavant

Diagnostic imaging has shown Kim Peek’s brain is a single hemisphere.

He is able to read two pages simultaneously. The left eye reads the left page and the right eye the right page in a matter of SECONDS!!!!!
Cerebral Cortex

Except for the “real” Rainman!
The basal ganglia are responsible for voluntary motor control, procedural learning, and eye movement, as well as cognitive and emotional functions.

Levels of somatic motor control
Fig 15.10: Central White Matter Communication Tracts

Tracts:
• Commisural
• Projection
• Association
Corticospinal pathway
(Pyramidal system)

The medial and lateral pathways:
(Extrapyramidal system)
Homunculus
Protection of the brain

*Bone (Skull)*

*Connective tissue (meninges)*

*Fluid (CSF)*
Figure 1: Cadaver cranial meninges

- Loose connective tissue and periorosteum of cranium
- Anterior
- Cranium (skull)
- Dura mater
- Epicranial aponeurosis
- Scalp
- Subarachnoid space
- Arachnoid
- Cerebral cortex covered by pia mater

(a) Superior view
Brain, cranium & meninges
Arachnoid granulation & CSF

- Cranium
- Dura mater (endosteal layer)
- Arachnoid granulation
- Fluid movement
- Superior sagittal sinus
- Arachnoid trabecula
- Dura mater (meningeal layer)
- Subdural space
- Pia mater
- Subarachnoid space
- Cerebral cortex
- Arachnoid
Circulation of CSF
Hydrocephalus
Fig 14.4 Lumbar Puncture (Spinal tap)

- Dura mater
- Epidural space
- Body of 3rd lumbar vertebra
- Interspinous ligament
- Lumbar puncture needle
- Cauda equina in subarachnoid space
- Filum terminale
Blood flow to the brain
The Circle of Willis

(a) Arteries of the brain, inferior view
Circle of Willis (up close)

(b) Arteries injected to show cerebral arterial circle
That’s a lot of blood vessels!
Angiogram of blood flow to the brain
Next!

Some medical conditions associated with aging!
But first a short break
WHAT THE BODY LOOKS LIKE TO THE BRAIN
It says the average person lives 657,000 hours.

Well, that would have been nice to know 632,000 hours ago!
# Presentation Outline

<table>
<thead>
<tr>
<th>Medical Issues</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td>Multiple Sclerosis</td>
</tr>
</tbody>
</table>
# Presentation Outline

<table>
<thead>
<tr>
<th>Medical Issues</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td>Multiple Sclerosis</td>
</tr>
</tbody>
</table>
Meningitis

- Inflammation of fluid & membranes (meninges) surrounding the brain & spinal chord

- Symptoms:
  - Fever
  - Rash
  - Headache
  - Stiff neck

- Cause: usually viral & bacterial infection due to meningococcus, hemophilus & pneumococcus

- Prevention/treatment:
  - by childhood vaccines & antibiotics.
  - Life threatening condition and classified as a medical emergency
Encephalitis  
(aseptic meningitis)

- Infections of the brain
- Many forms of encephalitis which are usually rare.
- Mostly present as a mild infection which is self-limiting.
- Some fatal forms

Symptoms:
- Mild to severe flu-like signs and symptoms — such as fatigue, weakness, aching muscles & joints, fever or headache
- Or, no symptoms at all.
- Confused thinking, seizures, or problems with movement or with senses such as sight or hearing, stiffness, swelling

Causes:
- Several causes but commonly inflammation of the brain by viral infection (rabies, tick, mosquito, herpes, measles)

Prevention/treatment: Vaccinations. Can be life threatening
# Presentation Outline

<table>
<thead>
<tr>
<th>Medical Issues</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td>Multiple Sclerosis</td>
</tr>
</tbody>
</table>
CIRCULATION
A Vascular Organ
STROKE
“Brain Attack”

- Sudden onset of neurological problems due to either blockage or rupture of blood vessels in the brain.

- Symptoms: paralysis (unilateral), slurred speech, confusion

- Causes: blockage (blood clot) from heart (Afib) or carotid artery or blood vessel rupture (aneurysm)

- Prevention/treatments: control blood pressure, cholesterol, medications (anticoagulants), tPA. (tissue plasminogen activator)
Causes of Stroke!
Hemorrhagic Stroke
Treatment With tPA

Before Treatment

After Treatment
tPA
(tissue plasminogen activator) at work
Stroke vs Transient Ischemic Attack ("mini-stroke": TIA)

**TIA**
- Interruption of blood flow is transient
- No brain damage

**Stroke**
- Interruption of blood flow is long-lasting
- Brain damage ensues
Bleeds vs Blockages

CT of the two types of stroke
Cerebral Aneurysm

- Occurs in 1 to 5% of adult autopsies
- Rupture is 1 in 10,000 per year
- Unruptured: Size matters <7mm good  >10mm bad
- In the US more unruptured aneurysms are treated than ruptured ones.
- Peak age 55 to 60
- Symptoms: Dramatic sudden headache (“Thunder Clap”), stiff neck, neurologic symptoms are none to brain dead
- Causes:
  - Underlying Disorders: Polycystic kidneys, Marfan, Ehlers Danlos
  - Risk in family members may be doubled
- Prevention/treatments:
  - >10% do not make it to hospital
  - Rebleed 4% in 48 hours, 30% in 2 weeks
  - Untreated mortality 45% in 30 days
Aneurysm Treatment

Clip

Coil
Berry Aneurysm

This type of aneurysm will burst and cause a subarachnoid hemorrhage.
Aneurysm Diagnosis

- CT scan
- Lumbar Puncture
- Cerebral Angiogram
  - MRA
  - CT Angio
  - Conventional (traditional) angiography
- 10% of SAH no cause on angio
# Presentation Outline

## Medical Issues

<table>
<thead>
<tr>
<th>Medical Issue</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td>Multiple Sclerosis</td>
</tr>
</tbody>
</table>
Brain Tumours

- Mass or growth of abnormal cells in the brain
- 150 different types
- Malignant or benign
- Localized or invasive
- Primary or Secondary (metastatic)
  - Primary eg: 80% gliomas (malignant)
  - Secondary eg: 10-15% meningiomas (benign)
- Symptoms: pattern of headaches, nausea/vomiting, vision & balance difficulties, tired, confused, seizures
- Causes: often not clear but exposure to radiation and family history seem important
- Prevention/treatment: surgery, brachytherapy, radiotherapy, gamma knife, chemotherapy
Glioma
Cat Scan Image
<table>
<thead>
<tr>
<th>Medical Issues</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td>Multiple Sclerosis</td>
</tr>
</tbody>
</table>
CIRCULATION
A Vascular Organ
Epidural and Subdural hemorrhages

- Bleeds on the outside of the brain
- Symptoms: Headache, loss of consciousness, confusion
- Causes: Both of these are traumatic.
  - The subdural hematoma occurs relatively rapidly after the trauma,
  - The epidural is much more insidious and can continue to expand and exert symptoms for weeks.
- Treatment: drilling a borehole through the skull into the hematoma and draining
## Presentation Outline

<table>
<thead>
<tr>
<th>Medical Issues</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td>Multiple Sclerosis</td>
</tr>
</tbody>
</table>
Dementia: Alzheimers

- Plaque & tangle buildup damaging healthy neurons
  - Plaque – clumps of protein (amyloid)
  - Tangles – fibrous tissue made up of tau protein
- Symptoms: Shrunken brain size, loss of communication skills & recognition, memory loss etc. Avg life expectancy 4 – 8 yrs after diagnosis
- Causes: ???High blood pressure & decreased blood supply
- Prevention/treatment:
  medications:
  - Aricept
  - Memantine
  - Exelon
  - Reminyl
Definition of Dementia  
(Canadian Government Dementia Statement)

“Dementia is a progressive and incurable disease for which a complete understanding of its pathophysiology and effective therapies to stop the progression are lacking.”
Dementia Types

- Alzheimers (70%)
- Vascular (15-20%)
- Lewy Body
- Frontotemporal
- Alcohol related
- Down Syndrome progresses to Alzheimers
<table>
<thead>
<tr>
<th>Stage</th>
<th>Teen</th>
<th>School age child</th>
<th>Preschool child</th>
<th>Baby</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Having hobbies, driving a car, getting a job</td>
<td>Able to be left unsupervised</td>
<td>Grooming: Hair, teeth, shaving, makeup, dressing</td>
<td>Walking (sitting up, crawling, standing, walking)</td>
</tr>
<tr>
<td></td>
<td>Planning and organizing tasks, preparing a meal, grocery shopping, laundry</td>
<td>Simple math and managing money. Reading. Being able to understand &amp; follow instructions</td>
<td>Toilet training: Continent bowels and bladder</td>
<td>Feeding (spoon fed, finger foods, spoon &amp; fork)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Talking: Able to express needs in words</td>
<td>Rolling over, sitting up and looking at the world</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sleeping and eating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Swallowing</td>
</tr>
</tbody>
</table>
Dementia Risk & Prediction

• The most sensitive predictor of early Dementia is a “change in gait”.

• Unable to predict progress as brain is affected at random

• Progressive decline can be slow or occur in abrupt “falling off a cliff” episodes

• Terminal Disease
Dementia: New Medication
Aduhelm (Aducanumab)

• Reduces Amyloid build-up
• 40% of patients have side effects (brain swelling & bleeds)
• Cost: US$28,000 per yr.
Parkinsons

- Death of cells in substantia nigra
- Leads to dopamine deficit
- Can cause Lewy Body Dementia
- Affects motor system
- Symptoms:
  - tremor,
  - rigidity,
  - slowness of movement
- Cause: unknown
  - Genetic? Toxic substances? Pesticides? Drugs? Head injuries?
- Prevention/Treatment:
  - Deep brain stimulation.
  - Medication: Levodopa/carbidopa combined in a single tablet. The brain tissue converts this drug to dopamine.
  - Utilization of Aptamers to prevent protein aggregation
Parkinson’s Disease Causes

Substantia Nigra → dopamine
Famous Parkinson’s Patients

Muhammad Ali & Michael J. Fox
At age 61 yr, Michael J Fox has lived with Parkinson’s for over 30 years

Utilization of Aptamers to Prevent Protein Aggregation in Parkinson’s Disease

• The abnormal aggregation of a protein known as alpha-synuclein appears to play a critical role in Parkinson's disease.
• This project will explore a new type of biomolecule, known as an aptamer, as a potential inhibitor of alpha-synuclein aggregation.
• Aim is to discover an aptamer with anti-aggregation properties and then test its ability to thwart alpha-synuclein aggregation.
• If these preliminary tests are promising, future work could explore how this aptamer could be used as a disease-modifying therapy.
• **Project Description:**
  Aptamers are short strands of DNA or RNA that fold up into 3D shapes that are capable of binding to a target molecule with remarkable specificity and affinity.
• Goal is to find a DNA aptamer that can bind tightly to alpha-synuclein and prevent it from aggregating.
“The Study and Treatment of Parkinson's Disease”

UVRA ZOOM Invitation via CURAC:

Date and time:
WEDNESDAY March 23, 2022; 7pm Eastern Time

Speaker:
Professor Maria DeRosa, Interim Dean, Faculty of Science, Carlton University, Ottawa Maria.DeRosa@carleton.ca

Short Overview:
Dr. DeRosa will describe:
1. the science of aptamers,
2. how the aptamers were discovered and characterized
3. their applications for the treatment of Parkinson’s

Registration:
Contact Susan Nesrallah susannesrallah@cunet.carleton.ca for a zoom invitation to this free event.
Parkinson's Surgery: Deep Brain Stimulation
Chronic Traumatic Encephalopathy (CTE)

- Diagnosis at autopsy
- 2 to 4.5 times increased risk of Alzheimers in later life
- ?? small number of mild trauma incidents or fewer severe incidents.
- Symptoms: Loss of consciousness, vision impairment, disorientation, repeated vomiting
- Causes: recurrent brain injury – concussion
- Prevention:
  - concussion protocols
  - head restraints: sports & aeronautics
  - helmet design: sports, cycling, skating, skiing etc.
Amyotrophic Lateral Sclerosis (ALS) 
Lou Gehrig’s Disease

- A progressive nervous system disease
- Affects nerve cells (motor neurons) in the brain and spinal chord
- Symptoms: Loss of voluntary muscle control, weakness, muscle wasting, eventual paralysis
- Causes:
  - 5 – 10% genetic
  - 90 – 95% unknown
- Prevention: Death 2 to 5 yrs from diagnosis
  
  Stephen Hawking lived >50yrs (76)
## Presentation Outline

<table>
<thead>
<tr>
<th>Medical Issues</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td><strong>Multiple Sclerosis</strong></td>
</tr>
</tbody>
</table>
Multiple Sclerosis:
Autoimmune disease of the central nervous system (brain & spinal cord)
What is MS?
Symptoms of MS

Visual disturbances (blurred vision, color distortions, loss of vision in one eye, eye pain)

Mental changes (decreased concentration, attention deficit, memory loss)

Loss of sensation, speech impediment, tremors, or dizziness

Depression, Paranoia, Uncontrollable laughter and weeping

Limb weakness, loss of coordination and balance

Muscle spasms, fatigue, numbness, prickling pain

Bladder and bowel dysfunction
## Presentation Review

<table>
<thead>
<tr>
<th>Medical Issues</th>
<th>Medical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral or bacterial <strong>INFECTION</strong></td>
<td>Meningitis, Encephalitis</td>
</tr>
<tr>
<td>Acute or chronic <strong>CIRCULATION</strong></td>
<td>Stroke, Aneurysms, Hemorrhage</td>
</tr>
<tr>
<td>Benign or malignant <strong>TUMOURS</strong></td>
<td>Glioma, Meningioma,</td>
</tr>
<tr>
<td>Acute or chronic <strong>TRAUMA</strong></td>
<td>Subdural or Epidural Hematoma</td>
</tr>
<tr>
<td>Acute or chronic <strong>DEGENERATION</strong></td>
<td>Dementia, Parkinsons, CTE, ALS</td>
</tr>
<tr>
<td>Acute or chronic <strong>INFLAMMATION</strong></td>
<td>Multiple Sclerosis</td>
</tr>
</tbody>
</table>
Some day, we will all die, Snoopy!

True, but on all the other days, we will not.