Brain Development and Toxins

Core Concepts:

- Brain development begins during embryogenesis and continues throughout life.
- Brain development involves cell division, cell death, cell growth and cell differentiation.
- The brain is sensitive to many environmental toxins which can have significant and long-lasting effects because of the central importance of the brain in human biology.

Class time required:

Approximately 2 X 40 minute class periods

Teacher Provides:

<u>For each student</u>

- Copy of student handout

<u>For Part 3 each team of 2-4 students:</u>

- Copies of **Neurotoxin Information Guide**
- Copy(ies) of **Patient Report**
    - assign 1 or more patients to each student group
- Copy of **Lab Test Instructions** (1 per student)
- 1 Copy of **Lab Test Sheet** (printed in color on paper and placed in sheet protector)
- 7 small tubes or cups (minimum 1mL capacity) - can be labeled and reused for multiple classes
- 6 squares Lead Test Paper = ½"X½" squares of Hydrion pH 1.0-12.0 Test Paper (WARD's #15W2561 Pkg of 5 (½" wide) rolls @ $20.55)
- Eye droppers or plastic transfer pipettes - can be labeled and reused for multiple classes (maximum 7 ** if testing all 4 patients)
- Goggles and gloves

Chemicals Needed (for multiple class periods (up to 5 classes of 30 students)**:**

** prices quoted from WARD's Natural Science Biology & Chemistry 2012 catalogue

- 100mL pH 3.00 Buffer Solution (WARD's #9405406 500mL bottle @ $13.15)
- 100mL pH 8.00 Buffer Solution (WARD's #9406106 500mL bottle @ $13.15)
- 100mL pH 12.00 Buffer Solution (WARD's #9405206 500mL bottle @ $13.15)
- 100mL 1% Phenolphthalein Solution (WARD's #9511504 100mL bottle @ $5.95)
- 100mL 0.05% Thymolphthalein Solution (WARD's #9512606 500mL bottle @ $15.55)
- 100mL 0.01% Bromothymol Blue (WARD's #9446904 100mL bottle @ $5.85)

SOLUTION & MATERIALS PREPARATION GUIDE (for each group of 2-4 students):

Tube Labeled	Solution
Patient #1	**pH 3** Buffer Solution
Patient #2	**pH 8** Buffer Solution
Patient #3	**pH 12** Buffer Solution
Organophosphate Test Solution	**pH 12** Buffer Solution
Patient #4	1% **Phenophthalein**
Alcohol Test Solution	.05% **Thymolphthalein**
Cortisol Test Solution	.01% **Bromothymol Blue**

Simulated Patient Samples:

- Small tubes or cups of Patient Samples to be used for all 4 tests - can be reused for multiple classes. These should be labeled and filled as follows:
  - **Patient 1** = 1-3mL **pH 3 Buffer Solution** with dedicated transfer pipette
  - **Patient 2** = 1-3mL **pH 8 Buffer Solution** with dedicated transfer pipette
  - **Patient 3** = 1-3mL **pH 12 Buffer Solution** with dedicated transfer pipette
  - **Patient 4** = 1-3mL 1% Phenolphthalein Solution with dedicated transfer pipette

LEAD TEST:

- **Lead Test Color Chart** – *consider laminating for use by multiple groups*
- Small bag labeled "**Lead Test Paper**" containing at least 6 squares of ½"X½" pH 1-12 test paper

ALCOHOL TEST:

- **Alcohol Test Color Chart –** *consider laminating for use by multiple groups*
- 1 small tube or cup with a designated plastic dropper (labeled and filled as follows):
  - **"Alcohol Test Solution**" = 1-3mL **0.05% Thymolphthalein Solution**

CORTISOL TEST:

- **Cortisol Test Color Chart –** *consider laminating for use by multiple groups*
- 1 small tube or cup with a designated plastic dropper (labeled and filled as follows):
  - **"Cortisol Test Solution**" = 1-3mL **0.01% Bromothymol Blue Solution**

ORGANOPHOSPHATE TEST:

- 1 small tube or cup with a designated plastic dropper (labeled and filled as follows):
  - **"Organophosphate Test Solution**" = 1-3mL **pH 12 Buffer Solution**

Suggested Class Procedure

Part 1

This part could be assigned as homework and then discussed in class as an introduction to the remaining parts.

Part 2

In this activity students learn about 6 key stages of brain development. They arrange illustrations that represent the key events associated with each stage. Students then answer questions about brain development.

Part 3

In this part students learn about different neurotoxins which can affect brain development. Working in groups of 2-4 students read short **Patient Reports** that highlight patient symptoms. Students then read brief descriptions about the effects of different environmental neurotoxins in the **Neurotoxin Information Guide**. Students use this information to select lab tests that simulate the techniques used to detect neurotoxins in patient samples. Based on the results of the lab tests, students identify the likely neurotoxin causing the patient's symptoms. Students then create a final report which indicates the possible developmental stage(s) affected by the toxins and use the **Treatments for Neurotoxin Exposures** guide to identify the treatment options for the patient.

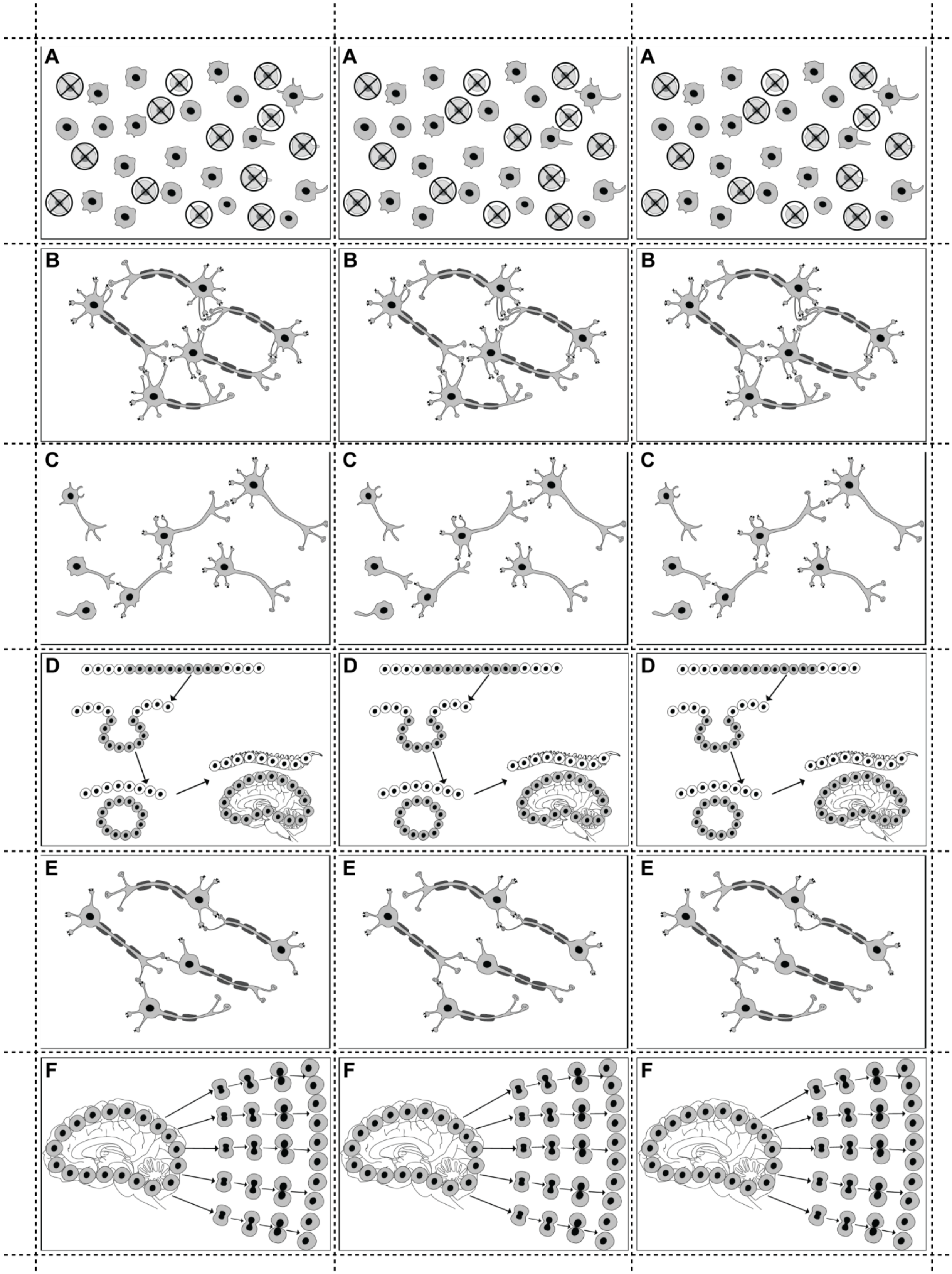
Note that the used **Lab Test Sheets**, which are printed onto paper and inserted into plastic sheet protectors may be stained by the test reagents. They can be cleaned by students after use by wiping with a wet hand wipe, or wet paper towel but the plastic sheet protectors may need to be replaced periodically.

Additional information/resources

National Scientific Council on the Developing Child, *Early exposure to toxic substances damages brain architecture.* (2006),Working Paper No. 4. *http://developingchild.harvard.edu/index.php/resources/reports_and_working_papers/working_papers/wp4/*

For Part 2

Brain Development Stage Illustration Cards



For Part 3

LAB TEST SHEET

Print in color and place in sheet protectors

Lead Test

Controls

\+ -

Patient 1

Patient 2

Patient 3

Patient 4

Alcohol Test

Controls

\+ -

Patient 1

Patient 2

Patient 3

Patient 4

Cortisol Test

Controls

\+ -

Patient 1

Patient 2

Patient 3

Patient 4

Organophosphate Test

Controls

\+ -

Patient 1

Patient 2

Patient 3

Patient 4

For Part 3

LAB TEST COLOR CHARTS

print in color on card stock and add to test kits

Cortisol Test Color Chart	
Cortisol Level (mcg/dL)	Color
0	
10	
20	
30	
40	
50	

Cortisol Test Color Chart	
Cortisol Level (mcg/dL)	Color
0	
10	
20	
30	
40	
50	

Cortisol Test Color Chart	
Cortisol Level (mcg/dL)	Color
0	
10	
20	
30	
40	
50	

Alcohol Test Color Chart	
Alcohol Level (%)	Color
0	
.01-.10	
.11-.20	
.21-.30	
.31-.40	
.41-.50	
.50+	

Alcohol Test Color Chart	
Alcohol Level (%)	Color
0	
.01-.10	
.11-.20	
.21-.30	
.31-.40	
.41-.50	
.50+	

Alcohol Test Color Chart	
Alcohol Level (%)	Color
0	
.01-.10	
.11-.20	
.21-.30	
.31-.40	
.41-.50	
.50+	

Lead Test Color Chart	
Lead Level (mcg/dL)	Color
0-5	
6-10	
11-20	
21-30	
31-40	
41-50	
51-60	
61-70	
70+	

Lead Test Color Chart	
Lead Level (mcg/dL)	Color
0-5	
6-10	
11-20	
21-30	
31-40	
41-50	
51-60	
61-70	
70+	

Lead Test Color Chart	
Lead Level (mcg/dL)	Color
0-5	
6-10	
11-20	
21-30	
31-40	
41-50	
51-60	
61-70	
70+	

For Part 3

Patient Reports

(Assign 1 or more patients to each student group)

Patient #1 13 year-old female

Patient Report:

Parents report that the patient has problems remembering things and focusing in school. Patient reports difficulty sleeping and having upsetting dreams. She has problems connecting to other students in school and can occasionally be aggressive with other students. She reports frequent stomachaches which cause her to miss school.

Patient #2 14 year-old male

Patient Report:

Patient recently started school and is having trouble adjusting to new school. Displays aggressive behavior toward peers and has difficulty paying attention. Parents say his teacher reports that he is having trouble keeping up with the work and frequently forgets what he is supposed to do next. His hearing is below average and he displays poor fine motor skills. He is of above average height and weight for his age.

Patient #3 17 year-old female

Patient Report:

Patient was delivered to the hospital unconscious. Friends who delivered her to the hospital expressed concern as this was not the first time something like this happened. Patient woke up briefly but speech was slurred and she could not remember what happened to her. Body temperature was 97.2˚F and heart rate was 55 beats per minute. A faint second heartbeat was detected and pregnancy test confirmed the patient is pregnant.

Patient #4 12 year-old male

Patient Report:

The patient woke up in the night and feeling pain in his chest. On examination, the patient was trembling and glassy-eyed with pinpoint pupils. During the examination, it was noted that the patient was sweating excessively, moaning and not moving his extremities. A regular heart rhythm and rapid heart rate of 149 beats per minute were the only additional findings.

For Part 3

Neurotoxin Information Guide

Lead Poisoning

Lead is one of the most common environmental toxins affecting more than 250,000 children aged 1-5 in the U.S.. The long term effects of lead poisoning are typically most severe when people are exposed before birth or in early childhood (before age 2-3) (**Figure 1**). Lead can have very significant effects on brain development because even at low levels in the body it can disrupt many of the steps of brain development including: neurogenesis (nerve cell mitosis), synaptogenesis (synapse formation), and myelination (insulation of axons).

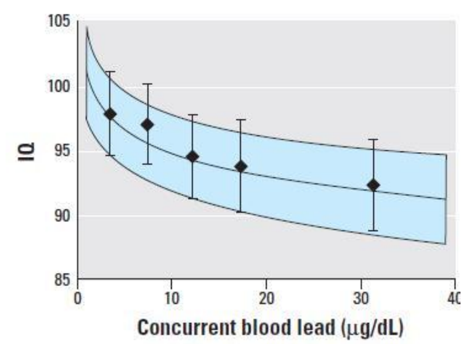
Symptoms:

Neurological

- Decreased IQ
- Reduced fine motor skills
- Loss of hearing
- Inappropriate emotional and/or social behaviors

Non-Neurological

- Reduced blood cell counts (anemia)
- Kidney problems
- Digestive problems (colic)



Lanphear et. al., (2005) Env. Health Perspectives 113(7)

Figure 1: Increasing blood lead level is strongly correlated with decreased IO.

Diagnosis:

Lead poisoning can be diagnosed through a **blood lead level** test.

Alcohol Toxicity

High levels of alcohol can have significant short and long term effects on the brain during adolescence. Short term, alcohol can disrupt the signaling in the brain that regulates breathing and balance (Table A). Long term, alcohol can disrupt pruning of excess synaptic connections.

Before birth, exposure to alcohol can lead to substantial decreases in nerve cell division and nerve growth. In addition, exposure to continuous high levels of alcohol prior to birth can lead to Fetal Alcohol Syndrome (FAS).

Symptoms:

Neurological

- Poor coordination and balance
- Slow reaction time and eye movements
- Inappropriate emotional and/or social behaviors
- Decreased IQ (long term)
- Reduced organizational abilities (long term)

Non-Neurological

- Altered facial features-upper lip and eyes (FAS)
- Decreased weight and height (FAS)

Table A: Biological Effects of Alcohol

Blood Alcohol Concentration (BAC)	Observable effects
0.02 - 0.049	• mild effects on body and behavior • slight body warmth
0.05 - 0.099	• sedation • slowed reaction time
0.10 - 0.19	• slurred speech • poor coordination • slowed thinking
0.20 – 0.29	• difficulty walking • double vision • nausea • vomiting
0.30 – 0.39	• may pass out • tremors • memory loss • cool body temperature
0.40 – 0.49	• difficulty breathing • coma • possible death
0.50 and greater	• death possible

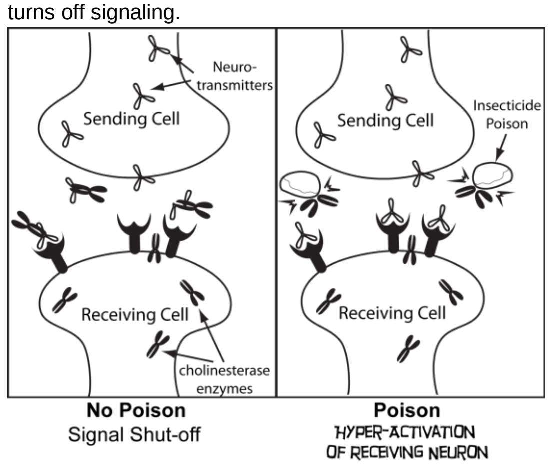
Diagnosis:

In cases of suspected alcohol poisoning a **blood alcohol test** should be given.

Organophosphate Insecticide Poisoning

Organophosphate type insecticides are present in commercial and household pesticides and certain flea and tick medications. They have also been used as nerve agents in warfare. If ingested or inhaled, these chemicals can interfere with cholinesterase, an enzyme that breaks down neurotransmitters and turns off nerve impulses at the synapse (**Figure 2**). Organophosphates can thus lead to hyper-activation of established neurons. Organophosphates can also interfere with development of new synapses when present in young children.

Figure 2: Organophosphates can lead to over activation of nerves by blocking the enzyme cholinesterase which turns off signaling.



Symptoms:

Neurological

- Seizures or trembling
- Anxiety
- Confusion
- Paralysis

Non-Neurological

- Altered heart rate
- Digestive problems (vomiting, diarrhea)
- Breathing problems

Diagnosis:

Insecticide poisoning can be measured through a **blood organophosphate test.**

Toxic Stress

Chronic long term intense stress can have toxic effects on brain development. Specifically intense and sustained stress leads to increases in circulating hormones like cortisol (**Figure 3**). When cortisol is increased during synapse formation and pruning of excess synapses it can lead to formation of negative connections in the brain or loss of positive linkages between brain regions. In addition to effects on the brain, toxic stress can lead to digestive problems.

Symptoms:

Neurological

- Reduced organizational abilities
- Difficulty sleeping
- Inappropriate emotional and/or social behaviors

Non-Neurological

- Digestive problems
- Decreased immunity

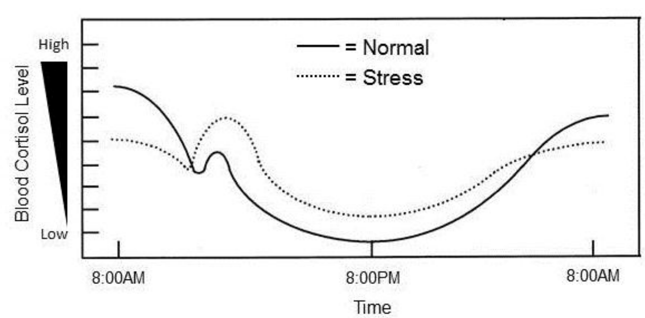


Figure 3: Cortisol levels in the blood change throughout the day. Chronic stress leads to increased blood cortisol levels primarily during the waking hours.

Diagnosis:

A **blood cortisol test** can be used to measure cortisol levels which can be an indication of toxic stress.

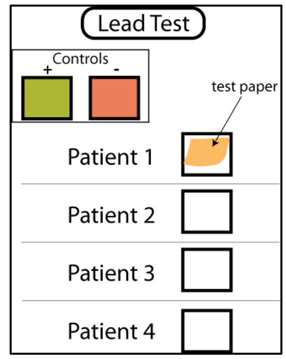
For Part 3

Lab Test Instructions

Be sure to follow the directions below for the test you are doing. Record your results in the tables of the **Patient Report**. Be sure to return any remaining test supplies when you are finished.

Lead Test Instructions

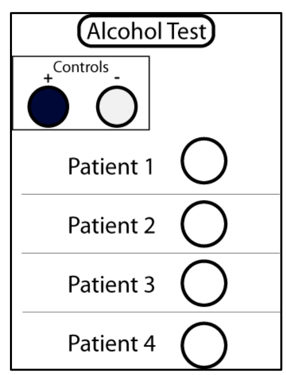
This test uses special paper which changes color when it reacts with lead in blood serum.



- Place small pieces of **Lead Test Paper** into **each patient sample space**.
- Using a transfer pipette place one drop of each **patient sample** onto the test paper in the appropriate **patient sample space**.
- Compare the colors of the Patient **Lead Test Paper** to the **Lead Test Color Chart** and record each patient's lead level in the Lead Test Table in the Lab Record

Alcohol Test Instructions

This test uses a chemical which changes color when it reacts with alcohol in blood serum.

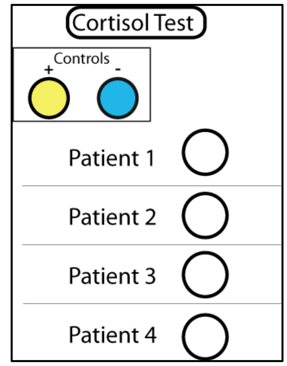


- Using a transfer pipette place one drop of each **patient sample** onto the test sheet in the appropriate **patient sample circle**
- Add one drop of **Alcohol Test Solution** to the patient samples
- Compare the colors of the **Patient samples** to the **Alcohol Test Color Chart** and
- Record each patient's alcohol level in the alcohol test table in the Lab Record.

<u>Cortisol Test Instructions</u>

This test uses a chemical which changes color when it reacts with cortisol in blood serum.

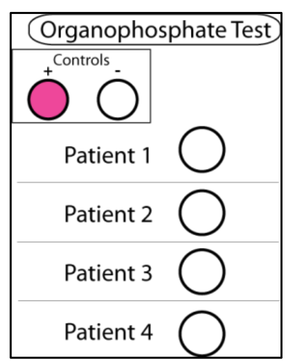
- Using a transfer pipette place one drop of each **patient sample** onto the appropriate **patient sample circle**.
- Add one drop of **Cortisol Test Solution** to the patient samples.
- Compare the colors of the **Patient samples** to the **Cortisol Test Color Chart**.
- <u>Record each patient's cortisol level in the cortisol test table in the Lab Record.</u>



<u>Organophosphate Test Instructions</u>

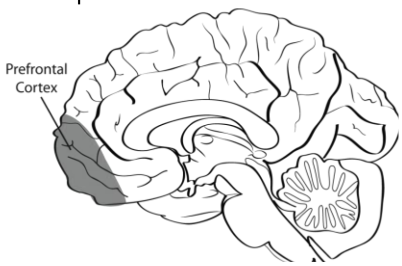
This test uses a chemical which changes color when it reacts with organophosphate in blood serum.

- Using a transfer pipette place one drop of each **patient sample** onto the appropriate **patient sample circle**.
- Add one drop of **Organophosphate Test Solution** to the patient samples.
- **Pink color change indicates that organophosphates are present in the sample**.
- <u>Record the results of each patient in the organophosphate test table in the Lab Record.</u>



PART 1 –The Neuroscience of Maturity

Figure 1: The Prefrontal Cortex, which is involved in decision making and impulse control continues to develop into adulthood



Biology Brief: The Neuroscience of Maturity

Neuroscientists now have evidence that the brain is still developing, even into your 20's. Changes in your brain's anatomy and function are still taking place during young adulthood, especially in prefrontal regions that are important for planning ahead, anticipating the future consequences of decisions, controlling impulses, and comparing risk and reward (**Figure 1**). Should this new knowledge prompt us to rethink what we allow people do to at certain ages (**Table A**)?

Table A: Legal boundaries between minors and adults

	Minimum Age
Driving	14-16
Working	14-15
Informed Consent	16
Rated-R Movie	17
Smoking	18
Voting	18
Military Service	18
Marriage	18-21
Drinking Alcohol	21

Maybe, but it's not as straightforward simple as picking one age where someone finally "grows up." Different brain regions mature at different times. There is no single age at which the adolescent brain becomes an adult brain. Brain systems responsible for logical reasoning usually mature by the time people are 16, but those involved in self-regulation are still developing in young adulthood. This is why 16-year-olds are just as able as adults to make decisions about their health care, but still immature about controlling their behavior. In fact, the Supreme Court has noted in several recent cases that a young person is less responsible than a 30 year old for his or her own criminal behavior. Using different ages for different legal boundaries would make the most neuroscientific sense.

But science has never had much of an influence on these sorts of decisions. If it did, we wouldn't have ended up with a society that permits teenagers to drive before they can see R-rated movies on their own, or go to war before they can buy beer. Surely the maturity required to operate a car or face combat is greater than the maturity required to handle sexy movies or to drink. Age boundaries are drawn for mainly political reasons, not scientific ones. It's unlikely that brain science will have much of an impact on these rules, no matter what the science says.

Adapted from "What the Brain Says About Maturity" (Laurence Steinberg, published in The New York Times May 28th, 2012)

Discussion questions:

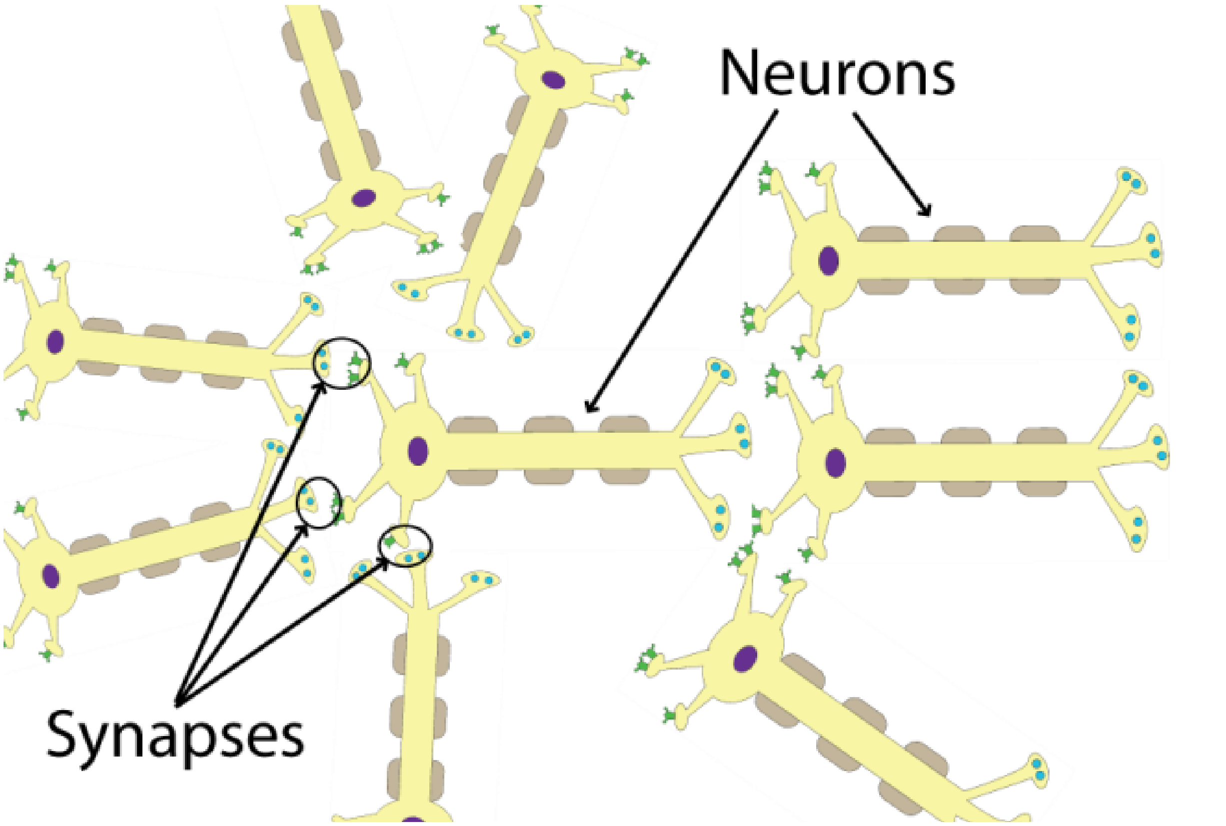
- Summarize what you learned from the article?
- Does the author believe that science should be used to make changes to the law? (Provide Evidence)
- At what age does the author suggest that the brain becomes fully mature?
- What are the advantages of using scientific findings to decide when you can and can't do things?

PART 2 –Brain Development

Biology Brief: Stages of Brain Development

In the introductory activities you learned that one **neuron** can communicate with another neuron across a **synapse**. Your brain is complex and **one neuron in your brain may receive input from as many as 1000 other neurons** (**Figure 1**). The connections among the neurons in your brain determine how you think, feel, behave, and communicate.

Figure 1: Neurons in the brain form synapses with many other neurons.



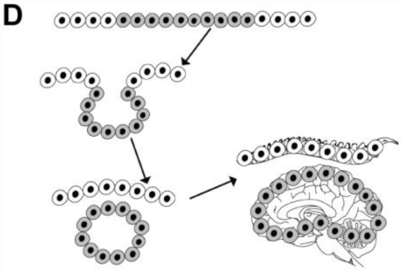
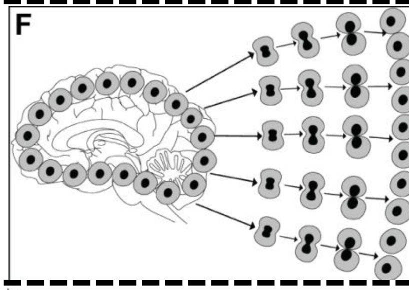
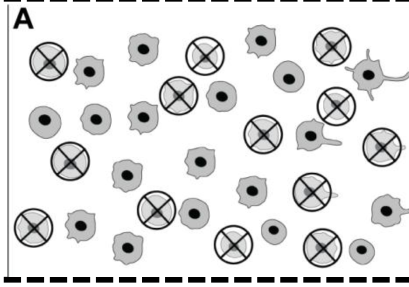
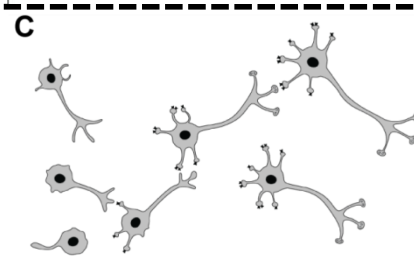
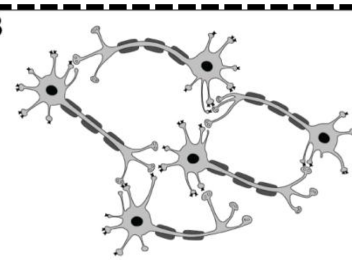
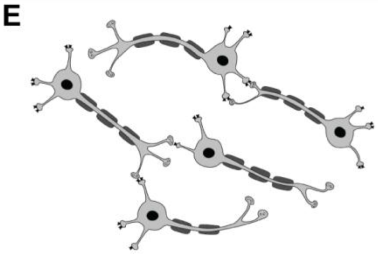
Where did these connections come from? How are they made, kept or thrown away? Unlike skin cells and blood cells, which are replaced many times during your life, most of the neurons in your brain are formed before you are born and will last a lifetime.

Activity- Card Sort

Brain development begins before you're born and continues all the way to adulthood. **Table A** on the following page presents some of the key steps in brain development that occur before (pre-natal) and after birth (post-natal).

- Read the descriptions under the column titled "**Key changes**".
- Then place the **Brain Development Card** that you think best illustrates the key changes described in the table in the space to the right.
- When you are finished, answer the questions which follow the table.

Table A: Stages of Brain Development (pre-natal = before birth, post-natal = after birth)

	Developmental Stage	Key changes	Select the illustration that best matches the key changes
Pre-Natal	1-4 weeks	• Cells in the outer layer of the embryo begin to differentiate into brain cells (neurons). These early neurons separate from non-neural cells and begin to form the shape of the brain.	D 
	5-12 weeks	• Brain cells go through mitosis (cell division) forming up to 100,000 new cells per second. By week 12 the developing brain has about 200,000,000,000 cells or about twice as many as an adult brain.	F 
	13-40 weeks	• Brain cells begin to die through programmed cell death, called apoptosis resulting in a loss of about half (50%) of the cells that had formed by week 12.	A 
Post-Natal	**0-2 Years Old**	• When a baby is born, she has about 100 billion brain cells with short axons and few connections to other neurons. From birth to age 2, new synapses form at the rate of up to 2 million new synapses each second. By age 2, there are about 1 quadrillion synapses. This gives babies the ability and flexibility to learn things quickly.	C 
	0-20+ Years Old	• Beginning at birth nerve axons are wrapped with a coat of myelin insulation which helps to dramatically speed up the rate of neuron communication. This myelination process continues into early adulthood and contributes to increases in brain size.	B 
	10-19 Years Old	• By the time you are 20, your brain has about half the peak number of synapses you had at age 2. This reduction in synapses, called pruning, occurs in your teens. It makes your brain more organized and effective. You can make quicker and clearer decisions BUT it slows your ability to learn new things.	E 

Refer to PART 2's **Table A: Stages of Pre-Natal Brain Development** above to answer the following questions.

Questions:

1. Record the order of the illustrations by entering the letter code on each card in the to the right of the correct developmental stage in the column labeled **Illustration letter code.**

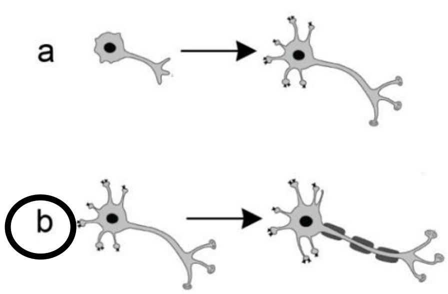
	Developmental Stage	**Illustration letter code**
Pre-Natal	1-4 weeks	**D**
	5-12 weeks	**F**
	13-40 weeks	**A**
Post-Natal	0-2 Years Old	**C**
	0-20+ Years Old	**B**
	10-19 Years Old	**E**

1. Complete the following sentences by circling or filling in the correct answer.
   - During adolescence synapses _**increase / decrease**_ through the process known as _**pruning**_.

   Which of the illustrations/steps in "Table A: Stages of Brain Development" helped you answer this question?

   ____

   - In the following illustration, which most accurately represents the process of myelination:



   Explain why you selected this choice.

   ____

   ____

2. Do you agree or disagree with the following statements. **Provide evidence**.
   a. Brain cells divide rapidly when a fetus is 5-12 weeks old. Agree or disagree? Explain your reason

   __**Agree. This is the time when nearly all neurons are formed.**______________

   ____

   b. Cells in the pre-natal brain die due to old age. Agree or disagree? Explain your reason.

   Disagree. Cells in the prenatal brain die due to apoptosis___________________

   ____

3. What might explain the large increase in brain weight that occurs in the first years of life? *(Circle one)*

   A. Increase in the number of neurons/cells in the brain through cell division

   B. Growth and myelination of existing neurons

   C. Changes in diet

   D. Increase in blood flow to the brain

Apply what you've learned…

Ever since she was little, 40-year-old Rachel had always wanted to learn to play an instrument. When Rachel's 9-year-old daughter, Eva, started taking violin lessons she thought she would too.

Now Rachel was frustrated. Eva had just played the tune on her violin perfectly while she was still struggling to learn the first part. Rachel couldn't understand why it was so much harder for her to learn the same thing that her daughter was learning!

4. Based on what you know about the brain why do you think Rachel (age 40) may have a harder time learning to play an instrument than her daughter, Eva (age 9)?

   __**Rachel's brain has fewer synapses compared to her daughter which makes it harder to learn new things which require communication between regions of the brain that did not communicate previously.**___________________________________

PART 3 –Brain Development and Toxins

Biology Brief: Toxins and the Brain
The brain is quite sensitive to **environmental toxins** for a number of reasons. For one the brain controls many biological processes so disruption of any part of the brain is likely to affect some aspect of life. Also because your brain doesn't regenerate easily, like blood and skin does, damage to the brain can be long lasting or permanent. Humans are especially sensitive before birth because the **blood-brain barrier**, which partly protects the brain from harmful chemicals and infections, is still developing and somewhat leaky. Also, the brain undergoes so many dramatic changes in size and shape before birth meaning toxins can disrupt major events in brain development.

Chemicals that can damage the brain are called **neurotoxins**. Neurotoxins can affect the brain in many ways. Some toxins affect specific stages of brain development while others can affect multiple stages of brain development. Some neurotoxins include: lead, found in paint dust and paint chips from homes built before 1978; alcohol, found in beer, wine and liquor; organophosphates (OR-GAN-OH-FOSS-FATES), found in insecticides; and even chronic stress, which can lead to long term changes in body hormones that can affect the brain.

Answer the questions below based on the Biology Brief: Toxins and the Brain

Questions:

1. What is a Neurotoxin?

   A neurotoxin is a chemical which can damage the brain______________________

2. List three examples of neurotoxins

   i___**Lead**______________________________

   ii.___**Stress**___________________________

   iii.___**Insecticides**______________________

3. At what stage of development is the brain most sensitive to toxins and why?

   __**The brain is most sensitive during pre-natal development. This is because the blood brain barrier is not fully formed. Also prenatal brain development involves_ major changes in size and shape. Toxins can thereby have large effects on brain development.______________________**_____________________________________

In this part you and your partner(s) will examine samples and case reports of patients with different symptoms. Your goal is to figure out what neurotoxins they may have been exposed to and what effects these neurotoxins can have on brain development

Lab Record

Instructions:

- Read the **Patient Reports**(s) and the **Neurotoxin Information Guide** carefully.
- Based on the patient symptoms and the information in the Neurotoxin Information Guide determine which toxin is most likely affecting your patient(s). This is your preliminary diagnosis, which is like a hypothesis.
- Record your preliminary diagnosis in the space below.

Patient #	Preliminary Diagnosis
1	*Stress*
2	*Lead*
3	*Alcohol*
4	*Insecticide*

- Determine which lab test(s) you wish to perform. You will need the following supplies:
    - Lab Test Instructions
    - Lab Test Sheet
    - Patient Sample(s)
    - Lab Test Supplies
- Follow the **Lab Test Instructions** carefully and enter in the results from the patient tests below.

Lead

Patient Sample #	Lead Level
1	
2	
3	
4	

Alcohol

Patient Sample #	Alcohol Level
1	
2	
3	
4	

Cortisol (Toxic Stress)

Patient Sample #	Cortisol Level
1	
2	
3	
4	

Organophosphate Insecticide

Patient Sample #	Organophosphate (+/-)
1	-
2	-
3	-
4	+

Biology Brief: Treatments for Neurotoxin Exposures

In the previous section you learned that the brain is sensitive to many neurotoxins and explored several examples. Exposure to a neurotoxin may require short term and long term treatment. In the short term treatment may be needed to remove the toxin and stabilize the patient to prevent death or disability. Over the long term, individuals may need ongoing support and therapy to help restore their brain function or to adapt to the effects of the damage.

Lead Poisoning:

Children diagnosed with lead poisoning are first treated with dimercaptosuccinic acid which binds to lead, prevents it from causing further damage, and helps eliminate it from the body. Children exposed to lead over a sustained period of time can often show problems with learning and memory. Research, originally performed in rats, indicates that providing these children with social supports like more stimulating learning environments can help reduce the effects of lead poisoning.

Organophosphate Poisoning:

Patients with organophosphate poisoning are usually given a drug like atropine which binds but does not activate neurotransmitter receptors on neurons. This prevents accumulated neurotransmitters from continuing to activate receiving neurons. Long term organophosphate poisoning has been linked to development of Parkinson's disease and dementia. Treatment for these long term effects may include a variety of medications that decrease the symptoms such as uncontrollable tremors.

Alcohol Toxicity:

Immediate treatment for ethanol intoxication is usually supportive and involves giving individuals intra-venous (IV) fluids until the body can break down the alcohol. In severe cases breathing and cardiac support may be needed to sustain life.

Cases of chronic alcohol abuse during adolescence can lead to Alcohol Use Disorder (AUD), resulting in a decreased ability in problem solving, verbal and non-verbal retrieval, visuo-spatial skills, and working memory. Treatment for individuals with AUD may involve various forms of psychotherapy, educational support, and possibly medication.

Prenatal exposure to alcohol can lead to Fetal Alcohol Syndrome (FAS). Children with FAS cannot be cured but a supportive and nurturing environment can help improve the prognosis for these individuals.

Chronic Stress:

The effects of chronic stress are first treated by avoiding or at least decreasing the stressful conditions. Long term effects of chronic stress can be treated with counseling and anti-anxiety medicines and/or anti-depressants. Studies have shown that the combination of talk therapy (counseling) and medicines can help individuals to make dramatic improvements.

Final Report

- Identify the toxins that are responsible for the symptoms of each patient.
- Refer to the **Neurotoxin Information Guide** and the **Brain Development Timeline** to provide a possible explanation for the symptoms the patient is experiencing.

4. Complete the table below

Patient #	Final Diagnosis
1	*Stress*
2	*Lead*
3	*Alcohol*
4	*Insecticide*

5. Select one toxin and answer the questions below

a. Toxin: _________________

b. Explain how the toxin affects brain development.

Lead—affects neurogenesis (prenatal 5-12 weeks), synapse formation (0-2 years) and pruning (10-19 years)

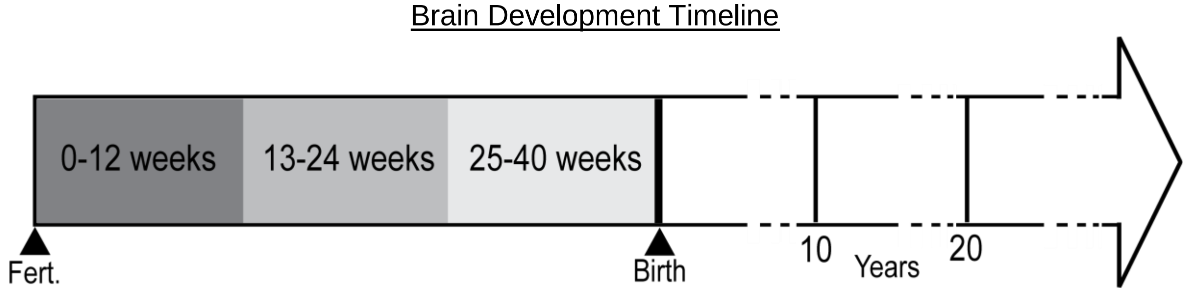
Stress—synapse formation (0-2 years) and pruning (10-19 years)

Insecticide—synapse formation (0-2 years), neuron signaling (0-20+)

Alcohol—neurogenesis (prenatal- 5-12 weeks), pruning (10-19 years)

c. Mark on the Brain Development Timeline below where the toxin(s) could have an effect. *You may mark more than one stage.*

Brain Development Timeline



d. What treatment(s) should be provided for a person exposed to this neurotoxin?

Answers will vary but should relate to the Biology Brief: Treatments for Neurotoxin Exposures

6. Which neurotoxin do you believe is the greatest threat to brain development and why? (You should consider how common the toxin is or how likely it is that someone could be exposed to the toxin.)

Student answers will vary but lead may be a popular answer because of its wide distribution in the environment and public awareness. Students may also point to alcohol because of their awareness due to school health education.