Brain Morsels: Packet 3

Sleep: "To sleep, perchance to dream."

Resilience and Gratitude, too

EACH BRAIN MATTERS
THE CENTER FOR NEUROSCIENCES FOUNDATION

"If only," many of us would say. Poor quality sleep, not enough sleep, daytime sleepiness. Plague of those who have lived for a long time.

Adequate sleep is one of the 5 key pillars in optimizing brain health, for any age really, but as we grow older, sleep sometimes becomes a challenge.

Our goal in this packet is to describe in understandable terms the biology of normal sleep, comparing sleep in the young adult brain and in the brain of typical elders. In the next packet, we will talk about what is known as sleep hygiene, practices that are highly recommended as approaches that aid the start and maintenance of sleep. We will not, however, discuss medications used to aid sleep; that is a topic to discuss with your physician!

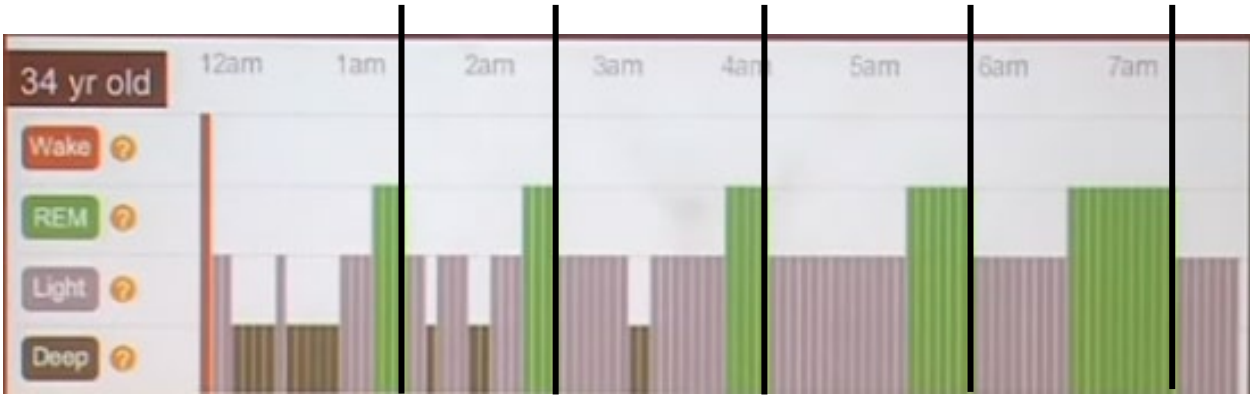
Let's begin asking what seems to be a simple question. All of us sleep so we *know* what sleep is, right? One wag described sleep as a symptom of caffeine deprivation. From the scientist's or clinician's perspective though, **sleep is a natural and readily reversible state of reduced responsiveness to and interaction with the environment, accompanied by a loss of consciousness. It's actually a highly regulated state, AND a very active state in terms of brain activity.**

As far as we know, all animals sleep, even fruit flies (they sleep in very short bouts, but they do sleep). This fact alone tells us that sleep is important physiologically. We know that rodents prevented from sleeping die. People significantly deprived of sleep develop cognitive and emotional problems that can include psychoses. As a guy named Jojo Jensen noted, "Without sleep we all become tall two-year-olds" (*Dirt Farmer Wisdom,* 2002). We also know that sleep deprivation has commonly been used in severe interrogations and as a form of torture.

[In case you're wondering about the panel with brain waves, there's an interesting adaptation in dolphins, air-breathing mammals that must surface to breathe and whose breathing is voluntary. To prevent drowning, dolphins sleep with half their brain at a time. The records from the dolphin show activity on the two sides, red for the right and blue for the left. In this recording the right side is at least semi-alert – indicated by the finer high-frequency waves, while the left side recording shows large waves consistent with deep sleep. Looking at the image, you can see that the flipper controlled by the awake side of the brain is extended while the one on the sleeping side is relaxed and hanging freely. This back and forth goes on for roughly 2-hr intervals.]

Now back to humans…

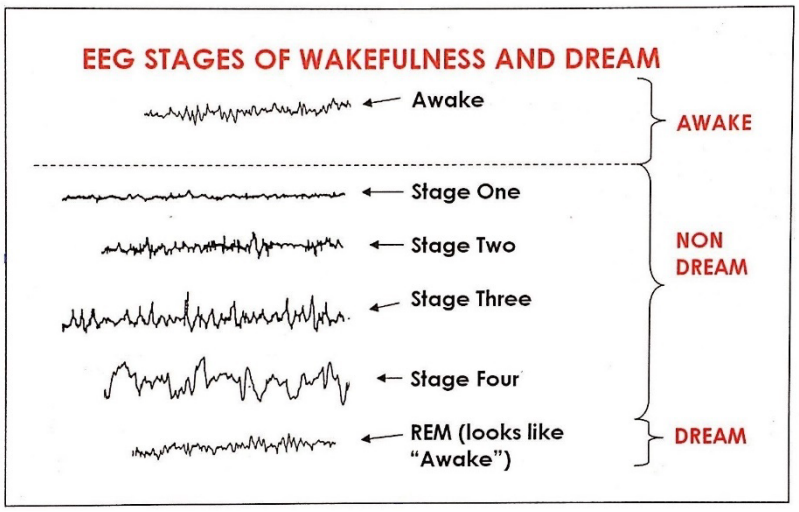
There is something called sleep architecture. Just a brief glance at the graph below shows why. In profile, it looks a bit like a city skyline.



This is a summary of typical records; yours may vary in the specifics, even quite considerably! Especially if you are an elder!

First – orientation to the graph. Look at the top half. The time bar at the top of each graph shows time through the night. A night's sleep is divided into 5-6 cycles. The vertical black bars show each sleep cycle. Each cycle is roughly 90 min long and during each one, the brain moves through several levels: first light sleep, in gray, then deep sleep, in dark gray, then back up to light sleep and finally into actively dreaming sleep (REM – rapid eye movement, which is a hallmark of REM sleep). Notice that in adults, most of the deep sleep is in the first few cycles and that there is more REM sleep in the later part of the night.

Here's a summary of the stages of sleep and the behavior that goes with it:



Notice the similarity between the recording of an awake brain and one in REM sleep! Hmmm!

Let's start with the awake state. Here sensation is vivid and is arriving from the external world. Thought is logical (mostly) and movement is continuous and voluntary.

Descent into sleep starts: Light sleep (stage 1), which is quite a transient stage, is when muscle activity slows down and there is occasional muscle twitching. Stage 2, descending further but still in light sleep, brings a slowing of breathing and heart rate. The brain recording (the EEG) is still fairly similar to one from an awake brain. Stages 1 and 2 are non-dreaming stages.

As we enter stages 3 and 4, also known as deep sleep, sensory information from the outside world is greatly reduced and the brain begins to generate slower waves. Muscle activity is much reduced, with occasional involuntary movements. Breathing becomes very rhythmic. There may be some simple dreams, but nothing beginning to approach the complexity of REM sleep dreams. There is no rapid eye movement.

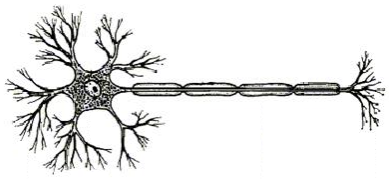
Deep sleep is a critical time. It's hard to awaken people from deep sleep and if awakened, people tend to be groggy and disoriented. Recordings of brain activity show long slow waves, produced by neurons acting in synchrony. Those waves spread from the front to the back of the brain and are slower and of higher amplitude than in light sleep or in the awake brain. You can see this in the electroencephalogram (EEG) recordings in the figure above. A deep structure in the brain, the thalamus, is acting to greatly reduce sensory input (sight, sound, touch) from the outside world to the cortex. The long slow waves spreading across the cortex then allow long-range communication between different parts of the brain and storage of memories at various sites. Deep sleep is when we store and strengthen new facts and skills (and why all-nighters to study don't work so well). It is also a time when the accumulation of waste products of neuronal

activity is washed out, preparing the brain for the work of the next day and allowing for removal of weak connections that are not important. It's restorative! Think of this as cleaning up the kitchen after a party!

During REM sleep (Stage 5), there are much faster brain waves that look a lot like awake brain waves, but again that sensory gate in the thalamus is closed to external input. It does, however, allow through signals of emotions and memories, especially in the areas of the brain that are responsible for associating information. That in turn allows information from across the brain's cortex to be integrated and in so doing build a better representation of the world. Information from across the brain is generated internally and some people experience vivid, illogical and bizarre dreams. Some remember them; some don't. Importantly, during REM sleep, skeletal muscles are effectively paralyzed, temporarily, which is a really good thing that prevents acting out those dream sequences. Bed partners could be seriously injured were that not the case!

REM sleep is important for storing and strengthening memories. During REM sleep in particular, there is strong activity in the visual, motor, emotional and autobiographical parts of the brain and much less activity in the prefrontal region. Connections among neurons are modified, strengthening or weakening them as needed. In ways we don't really understand, REM sleep is associated with memory, creativity and problem-solving.

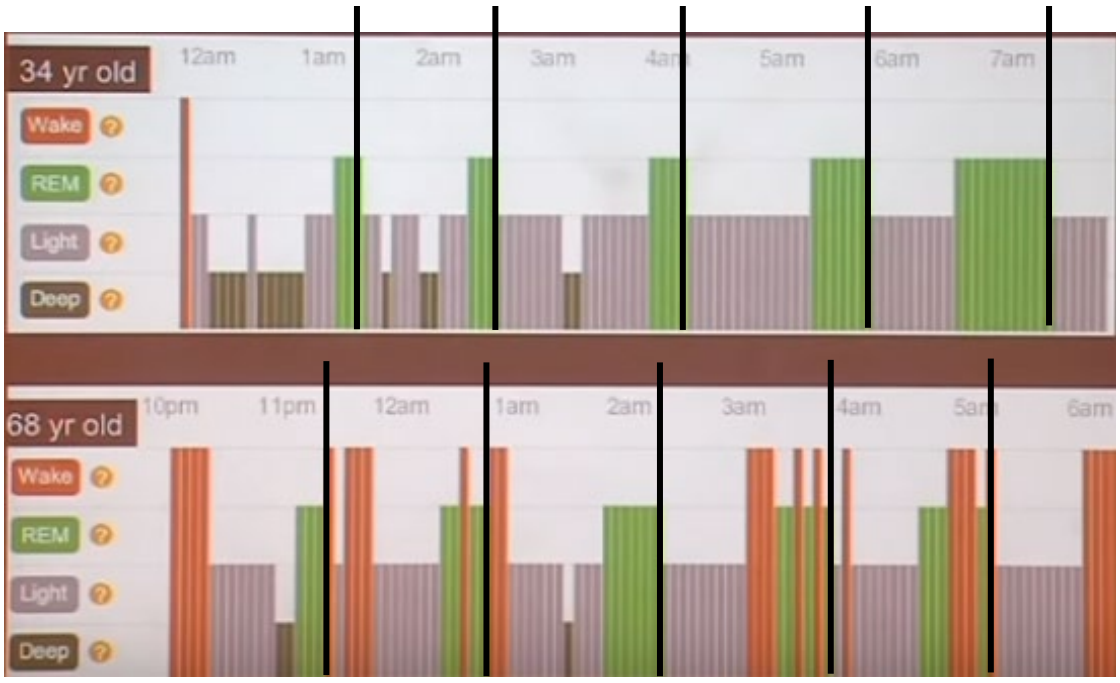
BTW, mammals and birds have REM sleep and, maybe, some lizards do too.



Comparison of sleep patterns in younger and older adults

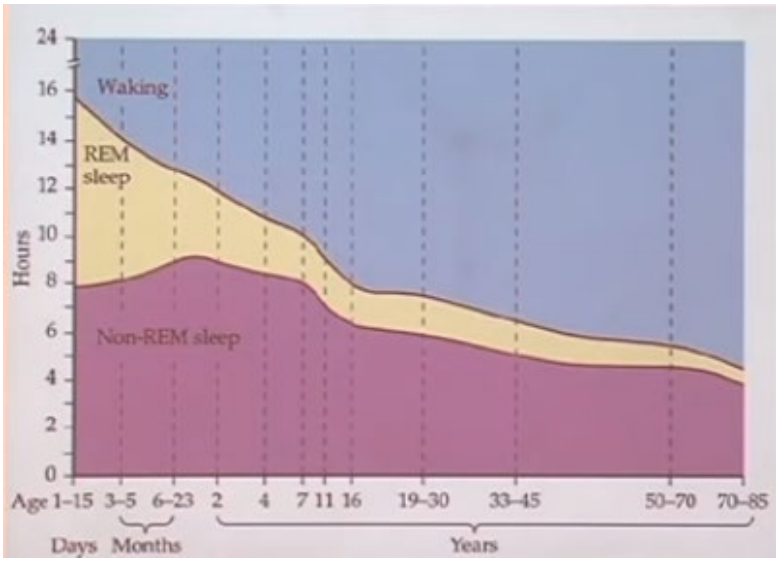
The image on the next page shows the sleep record from a 34-yr-old that you already have seen and now also one from a 68-yr-old. Compare the two sleep records. You will notice first the time of sleep onset. Onset is several hours later in the 34 -yr-old than in the older person.

In the older person's record, you'll see the same stages, but much less deep sleep and many more periods of awakening (orange). Sleep is fragmented, and there is less REM sleep. It takes longer to fall asleep, and elders spend more time in light sleep. In short, quality of sleep is lower as is amount of sleep. The graph below clearly illustrates these changes.

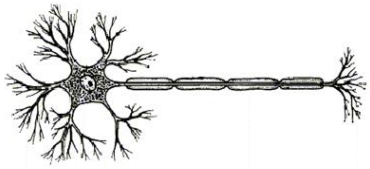


Here's an interesting side note: in some places in the world where during the night large animals, like elephants, often invade land being cultivated for food, adolescent boys are assigned to keep watch from platforms high in trees overlooking the fields. Adolescent sleep onset is usually much later, as their daily rhythm is physiologically shifted later. Their watch ends in the early hours of the morning – 1 or 2 AM, to be taken over by the early-rising grandfathers. Sleep duration often is much shorter in elders so, not a big problem.

This graph very clearly shows the changes that occur in typical sleep patterns over our lifetimes.



Age is shown on the horizontal scale; hours on the vertical scale. Blue is wake time, so elders clearly have less sleep. REM sleep, shown in yellow, diminishes, too. Purple - light and deep sleep, shows that deep sleep, which is restorative, also decreases.



Activity In Packet 2, you were asked to make a sleep diary.

Comparing your own data from the diary to those of a typical young-ish elder, the 68-yr-old in the example above:

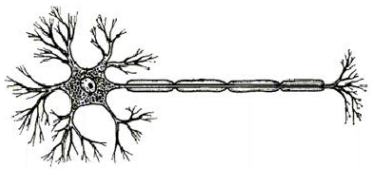
- What similarities and differences do you see?
- Would you consider yourself a morning person (a lark) or an evening person (an owl) or an "intermediate? (You have a chronotype based on your genes!)
- Do you feel rested when you wake up?
- Do you nap? If so, when and how long?
- Do you drink alcohol at night, or caffeinated drinks?

Here's a question for you. The best way to determine how much sleep you need is:

A. Ask your physician
B. Google "amount of sleep needed for an x-yr old person"
C. Figure out what amount *you* need to function well in the daytime
D. Complete the "drowsiness quotient" survey

The answer is 'C.' How do you do that? For a week or so, go to sleep when you are tired, not at some prespecified time. What time is that, on average? And what time would you wake up naturally with no alarms or other applied wake up signals? If you are waking up feeling well rested under this regime, that's how much sleep *you* need. The number of hours of sleep needed is somewhat variable from individual to individual, so just figure out what works for you and stick with it.

In the next packets, we'll talk about how your brain manages sleep-wake cycles. We'll discuss the consequences of sleep deprivation, especially chronic sleep deprivation, and we'll talk about ways that you might improve your sleeping without resorting to over-the-counter sleep aids, which often have a negative effect on your brain's sleep pattern.



Resilience

In an earlier packet, we talked about stress and asked you to think about ways that you manage stress. Many are the ways that help us build and strengthen our resilience to life's "slings and arrows." One way, with clear power as shown by research, is to embrace gratitude.

Gratitude and Your Brain

"Gratitude bestows reverence...changing forever how we experience life and the world." ~ *John Milton.*

You may think that the time for giving thanks is over till next Thanksgiving. But let's rethink that attitude to gratitude. Gratitude is defined as a state of thankfulness for and recognition of good things in your life, and it is no rinky-dink, passing emotion to be relegated to a single November day. Consider that in psychology research, gratitude is strongly and consistently associated with greater happiness. It helps people feel more positive, relish experiences, improve their health, deal with adversity, build strong relationships and generally have a better life. Pretty impressive, right? Neuroscientists agree and have carried out several studies to try and understand the neurocognitive processes associated with gratitude.

fMRI research connects gratitude with activity in two main regions of the brain - the anterior cingulate cortex (ACC), and the medial prefrontal cortex (mPFC). The ACC is thought to be important for the ability to feel, control and manage emotions. The mPFC is associated with social reward and interpersonal bonding and its activation with gratitude may promote more prosocial behaviors, i.e. those that move you to act for the greater good rather than just for yourself. Researchers have found that the stronger the feelings of gratitude, the stronger the blood flow and neuronal activation in these areas.

Scientists have also studied the neurochemistry of gratitude and it turns out that when we express gratitude, the brain releases several neurotransmitters. Dopamine is important in pleasure, reward, motivation and attention, and its release produces good feelings that may motivate you to repeat the behaviors that produce the feeling, such as expressing gratitude. Just expressing gratitude also enhances serotonin production in the ACC, leading to a more relaxed mood, and countering depression. Levels of oxytocin, a hormone associated with social bonding and trust, increase when we express gratitude. Finally, gratitude promotes brain release of endorphins which are associated with feelings of satisfaction and well-being.

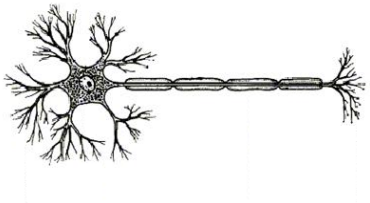
Clearly, gratitude is a powerful emotion, but you may wonder: Why does gratitude exist, anyway? Psychologists see gratitude as a pro-social emotion that orients us towards the welfare of others. It creates an enduring sense of trust and connection with another individual to whom you feel gratitude, and with whom you are prepared to cooperate. Gratitude makes you want to pay it forward and help others as you have been helped. That type of cooperation has been a key to survival and evolutionary success of our species.

Luckily, gratitude is not just an emotion but can become a skill cultivated by the regular practice of focusing attention on and savoring the good things and people in your life. When you consistently express gratitude, you change the neurochemistry and neural pathways of your brain, and over time it becomes an effortless and powerful habit. Our personal life stories are made up of lived experiences, and our experiences are made up of whatever we direct our attention to in the moment. Gratitude offers a way to reframe your experiences and rewrite a more positive story for yourself. And, who doesn't love a happy story?

So, explore some ways to practice gratitude (Google abounds with ideas).

Post by: *Nadia Fike*

Read More: ***1.***David DeSteno. *Emotional Success: The Power of Gratitude, Compassion, and Pride.* Houghton Mifflin Harcourt, 2018. ***2.***Hongbo Yu, et.al, Decomposing Gratitude: Representation and Integration of Cognitive Antecedents of Gratitude in the Brain. J Neurosci, 23 May 2018, 38 (21) 4886-4898; https://doi.org/10.1523/JNEUROSCI.2944-17.201



Puzzles

Puzzle 1

This is an imagining problem. How would you get two people to stand on a sheet of newspaper facing each other but not be able to touch each other?

Puzzle 2

Get yourself a bunch of toothpicks. Now use NINE toothpicks to make TEN. And then try using toothpicks to show that half of ELEVEN is SIX. This second one is hard – beware.

Puzzle 3

The day before two days after the day before tomorrow is Saturday. What day is it today?

Puzzle 4

Brain Fitness [From: E. Chudler, PhD. University of Washington]
http://faculty.washington.edu/chudler/neurok.html

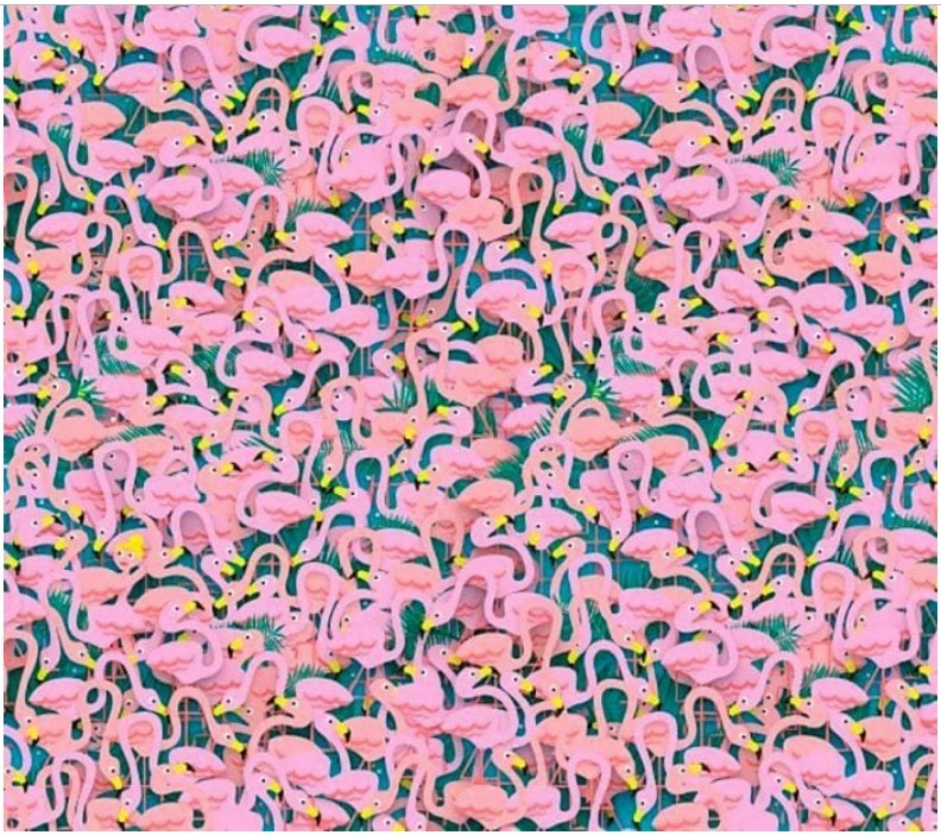
Z	S	R	R	B	Y	T	E	F	A	S	M	F	L	G
G	M	E	A	I	U	S	L	M	R	W	N	W	N	N
D	S	D	A	V	A	C	S	O	F	S	S	J	O	U
U	E	P	S	T	Q	L	T	A	T	I	I	A	I	T
S	H	D	I	B	B	N	C	R	I	W	I	B	T	R
B	R	A	I	N	E	E	O	H	N	S	E	V	C	I
B	T	Z	Z	D	A	P	L	O	J	O	H	G	E	T
D	T	N	I	P	S	L	I	T	U	I	G	O	T	I
I	I	C	E	I	A	S	R	I	R	X	U	R	O	O
M	C	V	D	M	S	E	L	C	Y	C	I	B	R	N
A	U	E	I	U	P	J	L	H	Q	M	L	G	P	K
V	J	T	C	N	Q	I	P	S	B	L	D	V	S	M
Q	A	N	O	F	G	A	U	K	H	F	V	H	W	J
H	O	F	Q	R	W	L	Q	Q	Y	N	W	P	A	U
C	Y	H	E	L	M	E	T	W	E	O	W	B	S	N

SEATBELT
INJURY
PROTECTION
CONCUSSION
HELMET
BICYCLE
SAFETY
SPORTS
DIVING
EQUIPMENT
NUTRITION
BRAIN
SPINAL
ACCIDENT

Puzzle 5

A Rest You're		Chair
	Mind Matter	Hea art
READING	AID AID AID	cycle cycle cycle

Puzzle 6 Find the hidden dancer.



COURTESY DANCEWEAR CENTRAL

Answers on the following page

Answers

Puzzle 1

Slide the newspaper under a door so that a person can stand on the newspaper on each side of the door but not touch. [Burns, Marilyn. *The Book of Think.* Boston, Little Brown and Co., 1976]

Puzzle 2

Use 9 toothpicks to form the letters in the word "TEN." Make the number 11 be written with toothpicks as a Roman numeral (XI). If you draw a horizontal line across the XI, you get the Roman numeral VI, which is 6.

Puzzle 3

It's Friday. The "day before tomorrow" is today; "the day before two days after" is really one day after. So, if "one day after today is Saturday," then it must be Friday. [https://parade.com/970343/parade/logic-puzzles/]

Puzzle 5
Row 1 – You're under arrest, I'm on top of the world, Highchair
Row 2 – Sandbox, Mind over matter, Heartbroken
Row 3 – Reading between the lines, First Aid, Tricycle

Puzzle 6
The ballerina is near the bottom left corner.