Nervous system, integration:

Some review & misc. parts **[Fig. 28.11B, p. 573]**:

White matter. Made up of myelinated sheaths (which cover axons and dendrites). It looks white because these sheaths are quiet fatty.

Gray matter. This consists mostly of nerve cell bodies, as well as axons and dendrites without the myelinated sheath.

Ventricles. These are spaces in the CNS that contain *cerebrospinal fluid*.

Cerebrospinal fluid moves nutrients, hormones and other substances around.

It also acts as a shock absorber, particularly in the brain.

Meninges **[Fig., not in text]**:

Nervous tissue generally has the consistency of watery jello. It's very fragile.

Meninges are made up of tough connective tissue and surround nervous tissue.

This helps protect nervous tissue; it also allows for cerebrospinal fluid to circulate.

In the brain, meninges consist of:

The *dura mater*, which is an an outer covering.

The *arachnoid membrane*, which is a space in the middle and is also filled with cerebrospinal fluid.

The *pia mater*, which is the inner membrane lying right over the brain.

The PNS, or Peripheral Nervous System:

This consists of paired *spinal nerves* and paired *cranial nerves* **[Fig. 28.11A]**.

Spinal nerves come/go to the spinal cord, cranial nerves come/go to the brain.

They are actually quite similar in structure.

Each set comes/goes to different structures. Except for a few cranial nerves (e.g. optic nerve), each set contains both sensory and motor components.

Mammals have 12 pairs of cranial nerves (other groups like reptiles only have 10).

The PNS is divided into two broad groups **[Fig. 28.12, p. 574. *NOTE: the fourth edition figure (28.12A) is NOT accurate*]**:

1) *Somatic* - has sensory and motor nerves,

These are the ones that you have voluntary control over and that sense the external environment.

2) *Autonomic* - generally not voluntary.

This includes nerves that serve the internal organs.

The autonomic system is actually divided into three parts, but let's skip the details.

Integration - or, how does all this work and fit together?

Example: a reflex arc (knee jerk reflex) **[Fig. 28.1B, p. 564]**:

Sensory neuron → CNS → motor neuron.

This is a very simple, straight forward pathway.

A *reflex* is a response that does not involve the brain.

Your leg responds without the brain being involved.

But - *you can feel* the response. So the signal does eventually get to the brain!

How does a sensory signal get to the brain?

There are two pathways that lead to the brain. Both cross over to the other side in the spinal cord **[Fig., not in book]**:

1) sensory neuron → thalamus → sensory cortex **[Fig. 28.15A, p. 577]**

Thalamus. this coordinates information coming from different parts of the body and sends it to the correct spot in the cortex.

Cortex. This is the outer layer of the cerebrum.

Cerebrum - higher functions take place here (more on this shortly)

The sensory cortex is a special part of the cerebrum (see below).

2) sensory neuron → cerebellum

The *cerebellum* is a major area of motor coordination and motor memory

For example, learning how to walk, play the piano or ride a bike.

Sensory cortex

This receives information from different parts of the body. Each part of the body can be represented on the surface of the sensory cortex **[Fig., not in book]**.

The area on the sensory cortex is related to the # of receptors at each part of the body

For example, the fingers have many more receptors, and also a much greater area on the sensory cortex.

There are other pathways going into the brain as well [illustrate on board]:

Optic nerve → (eventually) → thalamus → primary visual cortex.

Taste receptors → brainstem (pons, medulla) → thalamus → parietal lobe.

Auditory nerve → "superior olive" → thalamus → primary auditory cortex.

("superior olive" helps determine direction of sound).

Smell receptors → cortex → thalamus → other parts of cortex

[Note the difference in smell receptors].

To summarize, all these pathways eventually wind up in the cortex, which as mentioned, is the outer part of the cerebrum.

Cerebrum **[Fig. 28.16, p. 578]**:

This is a highly folded structure: it is surface area rather than volume that appears to contribute to intelligence

(Remember - the surface is where nerve cell bodies sit).

No other animal has as many ridges and grooves as man (corrected for size). Next in line are actually dolphins.

The cerebrum processes and integrates information from all parts of the body.

Different areas of the cortex can be mapped to different functions such as speech, pattern recognition, etc.

The cortex, particularly the frontal part, is where "intelligence" resides.

So, information is received and processed

Then, if needed, the appropriate action can be taken.

Another important part of the brain is the *corpus callosum.*

This moves information between the two halves of the cerebrum **[Fig. 18.15B, p. 577]**.

If some action (response) is taken or needed, then the motor cortex receives information from the following:

1) occipital lobe

2) temporal (hearing, memory, emotion)

3) parietal lobes (sensory, spatial)

→ all via the frontal association cortex, or lobe.

Motor cortex:

Very similar to the sensory cortex - it maps parts of the body on it's surface **[Fig., not in book]**.

If an electrical current is applied here, the appropriate body part will move.

BUT, it's not just a simple connection from the motor cortex to the muscle. There are actually two pathways:

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motor cortex → medulla (here connection crosses over to the other side)
        |               |
        |               |
        |               → motor neuron
        |
        → pons → cerebellum
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[Aside: please don't confuse cerebrum with cerebellum].

Why go to the cerebellum?

As mentioned, the cerebellum coordinates movement.

Information is processed, then taken BACK to the thalamus, then BACK to the motor cortex, and back down (add this pathway to the little figure above!).

cerebellum (processing) → thalamus → motor cortex

Remember that the cerebellum also gets information from the sensory nerves.

In this way the path has a loop in it, so movements can be refined as they take place

Since the sensory nerves also stop in the cerebellum, the cerebellum can coordinate sensory information with motor information.

The cerebellum makes sure you move your muscles/body in a way that actually works.

A few other brain parts to be aware of **[Fig. 28.15A, p. 577]**:

Medulla - controls breathing, heart and blood vessel activity, as well as other autonomous nervous system functions.

Pons - this is similar to the medulla, the best way to think of the pons is as a control center for the medulla.

Hypothalamus - As we know, this gets signals from all parts of the body and helps communicate with the endocrine system.

It is also responsible for sensations associated with "pleasure".

Some brain systems (usually composed of several parts of the brain) **[Fig. 28.20, p. 581 & not in book]:**

Limbic system - associated with the cerebrum, thalamus, hypothalamus, parts of the frontal cortex, as well as other parts.

Sorts through the information in the brain and determines the emotional content.

Reticular formation - associated with various parts of the brain, particularly the pons, medulla, and thalamus

Helps to control alertness.

By filtering information, the reticular formation can decrease alertness.

This might be useful when trying to get to sleep.

Some other examples of higher brain functions **[Fig. 28.16, p. 578]**:

As mentioned, various functions have been mapped to different parts of the cerebral cortex:

Speech - usually laterally, on the left side

Now suppose you sense an object with the left hand

This winds up on the RIGHT side (remember that nerve tracts cross over).

This information then travels through the corpus callosum.

If this arrives at the speech center, you can then tell someone what it is you're sensing.

But if the corpus callosum becomes severed, the information can no longer get to the left side of the brain.

A person can’t name the object anymore!

Right brain/left brain - this is also not as straight forward as it appears:

Important cultural differences have been found.

In different cultures, some association areas, may be on different sides of the brain.

It appears that the methods of learning/teaching are very important for these areas to develop.

In the U.S. and most western country we often have:

Left side - used for more analytical and mathematical reasoning.

Right side - used for spatial analysis, music, arts, etc.

But again, this can vary with the cultural background.

Another example: reading

Symbols wind up in the visual cortex, and are then moved to a part of the brain where they are translated into the equivalent of “sounds”.

When you read, you are actually translating symbols into “sounds”.

This complicated path is probably due to the fact that sound communication is much older than writing, so writing needs an extra step for interpretation.

Finally, just a little bit about long and short term memory.

This is a little more complicated, since there are also “*immediate memories*”.

Immediate memories:

Things you only remember while actually looking at them or hearing them, etc.

For example, the texture of the wall behind you, or the brake lights of the car in front of you.

These things do NOT stay in your brain.

Short term memories:

Memories that you can recall for a few seconds or so.

For example, a phone number, that you remember long enough to dial.

An address you remember long enough to write down.

Again, these usually don't stay in your brain.

Long term memories - memories that you can recall days, weeks, or even years later.

As usual, this is not straight forward.

For example, if you study hard for the final, you’ll do fairly well on the final.

BUT, try taking that same final a year later, and you probably won’t remember that much!

(Incidentally, memorizing stuff for an exam is putting things into long term memory!).

The process of going from short to long term memory is not well understood, but repetition helps.

Sometimes (e.g., a car accident), you can remember something that happened very quickly for years and years.

Long term memory involves the hippocampus. If this is damaged or removed, person’s can no longer learn (but previous events are still recalled clearly!).