1. **Fill in the blanks** to complete each pathway between a cranial nerve and its target. Provide **only one answer**, even if more are possible. The first is done for you. (10 pts)

<table>
<thead>
<tr>
<th>Cranial Nerve</th>
<th>First Opening</th>
<th>Second Opening</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glossopharyngeal, IX</td>
<td>jugular foramen</td>
<td>foramen ovale</td>
<td>parotid gland</td>
</tr>
<tr>
<td>Mandibular, V3</td>
<td>foramen ovale</td>
<td>mandibular foramen</td>
<td>lower teeth</td>
</tr>
<tr>
<td>Ophthalmic, V1</td>
<td>Superior orbital tissue</td>
<td>supraorbital foramen</td>
<td>forehead</td>
</tr>
<tr>
<td>Facial, VII</td>
<td>Internal auditory meatus</td>
<td>jugular foramen</td>
<td>trapezius</td>
</tr>
<tr>
<td>Maxillary, V2</td>
<td>foramen rotundum</td>
<td>infraorbital foramen</td>
<td>skin over lower eyelid</td>
</tr>
</tbody>
</table>

2. Meanwhile, back in the womb..... **Fill in the blanks**. (8 pts)

In the developing head, neural crest cells give rise to tissues that are derived from mesoderm elsewhere in the body. For example, many of the skull bones form by **intramembranous ossification** from connective tissue of neural crest origin. Other neural crest cells form **cartilage**, which later undergoes endochondral ossification to form bone. Most of the postcranial (inferior to the skull) bones are derived from **somatic lateral plate** mesoderm. An exception is vertebrae, which form from the **sclerotome** portion of the **paraxial** mesoderm. Muscle cells throughout the body originate from the **myotome** portion of the somites and somitomeres. **Endoderm** lining the third and fourth pharyngeal pouches contributes to the formation of the thymus and parathyroid glands.

3. **Autonomic** fibers in CN III are superficial, and so are the first affected by increased intracranial pressure (e.g. resulting from an extradural hematoma). What is the first symptom would you expect to see from compression of CN III? (2 pts)

   * dilated pupils

Page 1 Points missed: 0
4. The dilator pupillae is under sympathetic control. The route of a signal from the spinal cord to this muscle is shown below. Five steps do not belong and should be eliminated in order to create a correct sequence. **Circle the five errors.** (5 pts)

Preganglionic sympathetic cell body in lateral horn of gray matter at T1
- Dorsal root
- Ventral root
- Spinal nerve
- White ramus communicans
- Greater thoracic splanchnic nerve
- Sympathetic trunk/chain
- Celiac ganglion (no synapse)
- Superior cervical ganglion (synapse)
- Surround internal carotid artery to form carotid plexus
- Carotid canal
- Posterior cranial fossa
- Cavernous sinus
- Superior orbital fissure
- Ciliary ganglion (no synapse)
- Ciliary ganglion (synapse)
- Short ciliary nerve
- Dilator pupillae

5. **A) Complete** the table below by filling in the missing spaces. **Provide only one answer**, even if more are possible. (7 pts.):

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Innervation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral cricoarytenoid</td>
<td>Recurrent laryngeal n.</td>
<td>Adducts vocal ligaments</td>
</tr>
<tr>
<td>Posterior cricoarytenoid</td>
<td>Recurrent laryngeal n.</td>
<td>Abducts vocal ligaments</td>
</tr>
</tbody>
</table>
| Thyroarytenoid   | Recurrent laryngeal  | Elongates & tenses Vocal ligaments
| Cricothyroid     | External laryngeal n. | Moves thyroid cartilage anterior & inferior  |

B) **On the figure below, sketch in and label** the muscles listed in the table. (4 pts.)

![Diagram of vocal muscles](attachment:image.png)
6. Swallowing disorders, or "dysphagia", include any inability to move food or water from the mouth to the stomach. Stroke is the leading cause of "oropharyngeal" dysphagia, in which symptoms most frequently arise from the dysfunctional movement of food in the pharynx. Common manifestations include difficulty starting to swallow, choking, or nasal regurgitation.

A) What movements of normal swallowing are most likely affected to cause choking in patients with oropharyngeal dysphagia? (3 pts)
- Elevating the larynx
- Closing the epiglottis
- Over the trachea, and closing aryepiglottic folds

B) Name two muscles responsible for preventing nasal regurgitation in an unaffected individual, and provide their innervation. (2 pts)
- Tensor veli palatini - V\textsubscript{3} Mandibular
- Tensor veli palatini - IX Vagus

C) Laryngeal elevation is a key mechanism for protecting the larynx during swallowing, and can be tested for by simple palpation of the laryngeal prominence during a swallowing cycle. Which four muscles are active during laryngeal elevation? (2 pts)
- Thyrohyoid
- Salpingopharyngeus
- Stylopharyngeus
- Palatopharyngeus

7. Using the choices listed below, complete the following table so that each row contains structures consistent with each cranial nerve. Each choice will be used once. (10 points)

<table>
<thead>
<tr>
<th>Cranial nerve</th>
<th>Named branch</th>
<th>Ganglion</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oculomotor nerve</td>
<td>Short ciliary nerve</td>
<td>Ciliary ganglion</td>
<td>Ciliary body</td>
</tr>
<tr>
<td>Facial nerve</td>
<td>Chorda tympani</td>
<td>Submandibular ganglion</td>
<td>Submandibular gland</td>
</tr>
<tr>
<td>Facial nerve</td>
<td>greater petrosal nerve</td>
<td>Pterygopalatine ganglion</td>
<td>Nasal mucosa</td>
</tr>
<tr>
<td>Glossopharyngeal nerve</td>
<td>Tympanic nerve</td>
<td>Otic ganglion</td>
<td>Parotid gland</td>
</tr>
<tr>
<td>Vagus nerve</td>
<td>internal laryngeal nerve</td>
<td>Jugular ganglion</td>
<td>Laryngeal mucosa</td>
</tr>
</tbody>
</table>

**Table Entries:**
- Tympanic nerve
- Short ciliary nerve
- Chorda tympani
- Greater petrosal nerve

**Ganglion Entries:**
- Pterygopalatine ganglion
- Submandibular ganglion
- Otic ganglion
- Jugular ganglion

**Target Entries:**
- Nasal mucosa
- Laryngeal mucosa
- Submandibular gland
- Parotid gland
- Ciliary body
8. For each of the following limb regions, **name one muscle** you would find there, and **name the nerve** that innervates that muscle. (11 pts)

<table>
<thead>
<tr>
<th>Region</th>
<th>Muscle</th>
<th>Nerve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior compartment of the arm</td>
<td>biceps brachii</td>
<td>musculocutaneous</td>
</tr>
<tr>
<td>Posterior compartment of the arm</td>
<td>triceps brachii</td>
<td>radial nerve</td>
</tr>
<tr>
<td>Thenar eminence</td>
<td>opponens pollicis</td>
<td>recurrent branch of median nerve</td>
</tr>
<tr>
<td>Anterior compartment of the forearm</td>
<td>flexor digitorum</td>
<td>median nerve</td>
</tr>
<tr>
<td>Posterior compartment of the forearm</td>
<td>extensor digitorum</td>
<td>radial nerve</td>
</tr>
<tr>
<td>Anterior compartment of the thigh</td>
<td>rectus femoris</td>
<td>femoral nerve</td>
</tr>
<tr>
<td>Posterior compartment of the thigh</td>
<td>semimembranosus</td>
<td>sciatic nerve</td>
</tr>
<tr>
<td>Medial compartment of the thigh</td>
<td>adductor brevis</td>
<td>obturator nerve</td>
</tr>
<tr>
<td>Posterior compartment of the leg</td>
<td>soleus</td>
<td>tibial nerve</td>
</tr>
<tr>
<td>Anterior compartment of the leg</td>
<td>tibialis anterior</td>
<td>deep peroneal nerve</td>
</tr>
<tr>
<td>Lateral compartment of the leg</td>
<td>peroneus longus</td>
<td>superficial peroneal nerve</td>
</tr>
</tbody>
</table>

9. **Jugular foramen syndrome** is a multi-nerve palsy that involves all cranial nerves that pass through the jugular foramen. (8 pts)

   A) What nerves will be affected?
   - glossopharyngeal, vagus, spinal accessory

   B) Describe a simple motor OR sensory test to assess the function of each nerve.
   - sensation on posterior 1/3 of tongue
   - speaking
   - shrugging shoulders
10. Cerebral arterovenous malformation (AVM) is a congenital malformation of the arteries and veins of the brain. Instead of meeting at capillary beds, major arteries shunt directly to veins, forming a tangle of vessels called a nidus (or nest). These structures are generally asymptomatic until a rupture occurs at the site. Patients often present with loss of consciousness, sudden and severe headache, nausea, vomiting, and various sensory deficits depending upon the location of the bleed. Senator Tim Johnson (D-SD) was recently diagnosed with bleeding from an AVM and is currently recovering.

A) During an AVM bleed, what meningeal space does the blood flow into? (2 pts)
   Sub-arachnoid

B) Is this considered a potential space or an actual space? (2 pts)
   Actual Space

C) Specify which meningeal layers bounds this space in each direction. (2 pts)
   Deep: pia mater
   Superficial: arachnoid mater

D) AVM bleeds can be treated with embolization (occlusion) of the vessels involved. If the right anterior cerebral artery needs to be embolized, the areas it supplies will have to receive collateral circulation. What specific regions of which lobes of the brain receive blood supply from the anterior cerebral artery? (2 pts)
   Medial regions of frontal & parietal lobes

11. Name a structure that has the following spatial relationship. Give only one answer per relationship, even if more are possible. (11 pts)

A) Passes through the foramen spinosum.
   Middle meningeal artery

B) Crosses anteriorly across the masseter muscle, then dives deep through the buccinator muscle.
   Parotid duct

C) From the posterior wall of the middle ear to the neck of the stapes.
   Stapedius muscle

D) Between the lentiform nucleus (globus pallidus + putamen) and the thalamus.
   Internal capsule

E) Travels anteriorly, embedded within the roof of the maxillary sinus.
   Intraorbital nerve
F) Travels through the cavernous sinus, completely surrounded by venous blood.
   
   Carotid artery

G) Pierces the thyrohyoid membrane to enter the larynx.

   Internal laryngeal nerve

H) Runs vertically along the anterior surface of the anterior scalene muscle.

   Phrenic nerve

I) Runs from the pterygoid plate to the medial aspect of the angle of the mandible.

   Medial pterygoid muscle

J) Sits on top of the arytenoid cartilage.

   Cricotracheal cartilage

K) Travels through the optic canal.

   Optic nerve

12. Circle the correct answer: (2 pts)
A newborn male is found to have urethral openings along the ventral surface of the penis. The physician explains to the parents that the bilateral structures that should have fused in the midline failed to fuse completely, and this resulted in the defect. The parents are very concerned, but the physician reassures them that this can easily be surgically corrected. Which of the following structures in a female normally develop from the same structures that failed to fuse in this boy?

   a. Round ligament of the uterus
   b. Crura of the clitoris
   c. Labia majora
   d. Labia minora
   e. Ovarian ligaments

13. Circle the correct answer: (2 pts)
When removing an impacted mandibular third molar, the oral surgeon must warn the patient of possible lasting numbness of the tip of the tongue. This loss of general sensation is due to damage to the

   a. Auriculotemporal nerve
   b. Chorda tympani
   c. Lingual nerve
   d. Mental nerve
   e. Mylohyoid nerve

Points missed: _____
14. The diagram at right shows electromyograms (EMGs) of some of the muscles of mastication during chewing. L. Mass and L. Temp. are left masseter and left temporalis, respectively. L. Med. Pt. and R. Med. Pt. are left and right medial pterygoid. FC is the fast closing stage of mastication, PS is power stroke, SO is slow open, and FO is fast open.

A) Use the graph to determine whether the food bolus is in the left or right side of the mouth? (Explain your answer in terms of the muscle EMG activity.) (2 pts)

Rt. Med. Pt. is active during the power stroke. This means that the jaw shifts left during the PS, making left the balancing side. The food bolus is therefore on the right.

B) What are the primary functions of the masseter and temporalis muscles during mastication? (2 pts)

Elevation of the mandible (both muscles)
Temporalis also retracts the mandible

C) What are the functions of the sternohyoid and mylohyoid muscles during mastication? (2 pts)

Sternohyoid fixes the hyoid so that the mylohyoid can depress the mandible

D) What is the function of the mylohyoid during Stage 1 of swallowing? (1 pt)

Elevating the hyoid
15. Using the diagram of an embryo above, **name the adult structure(s)** that the numbered embryonic structures will develop into. (6 pts)

Structure 1 will develop into **lungs**
Structure 2 will develop into **liver** and **gall bladder**
Structure 3 will develop into **bladder**
Structure 4 will develop into **testes/ovaries**
Structure 5 will develop into **kidney**

16. **Indicate the primary germ layer** each of the listed structures develops from. Be as **specific as possible** when describing mesodermal and ectodermal derivatives. (8 pts)

- intercostal muscles
- erector spinae muscles
- frontal bone
- parietal peritoneum
- testes
- somatic sensory neurons
- somatic motor neurons
- spleen

- hypoderm of myotome of paraxial mesoderm (PA)
- epimere of myotome of PAM
- Neural crest cells (ectoderm)
- Somatic Lateral Plate mesoderm (LPM)
- genital ridge of intermediate mesoderm
- Neural crest cells
- Dorsal hollow nerve tube (ectoderm)
- Splanchnic LPM

Page 8
Points missed: 0
17. You believe that a patient complaining of generalized abdominal pain has some problems with the abdominal circulation. An abdominal angiogram, performed by injecting contrast material in the main abdominal vessels through a femoral catheter, shows stenosis (abnormal narrowing of a blood vessel) of the superior mesenteric artery (SMA), near the base of the vessel.

A) **Name** the blood vessels the catheter passed through, from the femoral artery to the superior mesenteric artery. (2 pts)
   
   Right femoral a. → right external iliac artery → right common iliac artery → abdominal aorta → SMA

B) **Name** the gut tube structures affected by the decreased blood flow. (2 pts)
   
   distal duodenum, jejunum, ileum, cecum, appendix, ascending colon, proximal 1/3 of transverse colon

C) **Trace the path** followed by the contrast material injected in the SMA on its way to the right coronary artery, naming arteries, veins, capillary beds and chambers of the heart along the way (7 pts)
   
   SMA → intestine capillary bed → superior mesenteric vein → hepatic portal vein → portal capillary bed → liver → hepatic vein → inferior vena cava → right atrium → right ventricle → pulmonary trunk → pulmonary artery → lung capillaries → pulmonary veins → left atrium → left ventricle → aorta → right coronary artery

18. **Answer** the following questions in reference to the figure below (5 pts)

   a) The left lingual artery receives blood from **which numbered vessel**? 2

   b) Fluid drained by the lymphatic system will enter which vessel first? B

   c) In a patient with patent foramen ovale, which heart chambers will have mixed blood? D, E, A, F e + A → 1/2

   d) ____ receives blood that has been most recently in the myocardial capillary beds.

   e) Venous blood returning from the kidney would enter which vessel first? H

Page 9 Points missed: 1/2
19. Occlusion of the brachiocephalic trunk is rare, but can occur in association with cardiovascular disease. In such cases, arterial anastomoses can supply blood to the affected areas of the brain. **Trace two possible pathways** for a red blood cell traveling from the left ventricle to the right middle cerebral artery in a patient with an occluded brachiocephalic trunk. **Name the vessels traveled** and the site of entry into the skull. **Note:** your pathways must enter the skull at different locations. (12 pts)

Path 1: Left ventricle → Aorta → Left common carotid artery → Left internal carotid artery → Carotid canal → Cavernous sinus → Left posterior communicatory artery → Left posterior cerebral artery → Basilar artery → Right posterior cerebral artery → Right posterior cerebral artery → Right internal carotid artery → Right middle cerebral artery

Path 2: Left ventricle → Aorta → Left subclavian artery → Left vertebral artery → Foramen of transverse processes C6-C7 → Foramen magnum → Basilar artery → Right posterior cerebral artery → Right posterior communicatory artery → Right internal carotid artery → Right middle cerebral artery

20. Loss of the corneal reflex (blinking in response to the cornea being touched) is a sign of damage to which cranial nerve? (2 pts)

[Diagram]

21. A patient presents complaining of diplopia (double vision). When you ask her to look straight ahead, you see a medial deviation of the left eye. Assuming this medial deviation is due to a motor deficit, what muscle is involved? What nerve is affected? (4 pts)

Lateral rectus
Abducent nerve (VI)

- 4 = 146/150 = 97%
Course Avg. = 97%
1. R. Corpus Collosum
   B. foramen of Monroe
2. R. inferior concha
   B. 2
3. R. facial nerve
   B. 2nd
4. R. Carotid artery
   B. nasolacrimal duct
5. R. basilar artery
   B. posterior communicating artery
6. R. lingual nerve
   B. levator veli palatini
7. R. inferior alveolar nerve
   B. temporalis muscle
8. R. internal carotid artery
   B. body of C3
9. R. greater petrosal nerve
   B. pterygoid canal
10. R. pons
    B. sensory, branchiomotor
11. R. zygomaticus major
    B. tightly closing eye
12. R. incus
    B. 1st
13. R. eustachian tube
    B. Salpingo Pharyngeus muscle
14. R. anterior scalene
    B. omohyoid
15. R. genioglossus
    B. infraorbital nerve
16. R. lingual nerve
    B. general sensory, special sensory, parasympathetic
17. R. glossopharyngeal nerve
    B. vallate papilla
18. R. lateral pterygoid
    B. medial pterygoid
19. R. mental nerve
    B. depressor anguli oris
20. R. styloglossus
    B. hypoglossal nerve (CN XII)
21. R. posterior cricoarytenoid
    B. recurrent laryngeal nerve of vagus (X)
22. R. medial rectus
    B. oculomotor (CN III)
23. R. posterior belly of digastric
    B. middle meningeal artery
24. R. internal capsule
    B. putamen
25. R. hypoglossal nerve (CN XII)
    B. hypoglossal canal