FIGURE 1. The “five-pointed star” of neurosurgical education.
The goals of the AANS, CNS, SNS, ABNS, and RRC were aligned for the development of the Matrix curriculum.

**Synthesis of Goals**

- **AANS and CNS**
  - Education content

- **SNS**
  - Committee on Resident Education (CoRE)

- **ABNS (certification)**
  - Written and Oral Exams

- **RRC (accreditation)**
  - Training environment

Both organizations deal with medical knowledge and technical skills.
FIGURE 3. The development of the Matrix curriculum was a project coordinated through the efforts of the SNS, ABNS, and RRC. The AANS and CNS participated in the development through their Joint Sections and Executive Committees. The curriculum re-design represented by the Matrix curriculum process was the first of its kind in medical education.

SNS Matrix

• Neurological Surgery developed a process to redefine residency curriculum
• This project coordinated the efforts of SNS, ABNS, and RRC.
• The AANS and CNS participated through their Joint Sections, and Executive Committees
• The Matrix Project was the first of its kind in medical education and Neurological Surgery has been recognized by the ACGME as the forerunner in curriculum re-design
FIGURE 4. The Matrix is a comprehensive curriculum for neurological surgery, developed by the SNS Committee on Resident Education (CoRE), which incorporates the RRC case categories and ABNS written examination question content categories. Each competency is broken down into Objective, Teaching Methods, Assessment Tools, and Educational Goals.

Matrix (circa 2011)

<table>
<thead>
<tr>
<th>Competency</th>
<th>Objective</th>
<th>Teaching Methods</th>
<th>Assessment Tools</th>
<th>Educational Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Knowledge</td>
<td>Lumbar Puncture</td>
<td>AANS/SNS On-line modules</td>
<td>Faculty and Program Director evaluations</td>
<td>Proficient (4)</td>
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<td>(Technical Skills)</td>
<td>Ventriculostomy</td>
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<td>CSF Sample</td>
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<td>Shunt tap</td>
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<td>Traction</td>
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<td></td>
<td>Stereotactic frame placement</td>
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</tr>
</tbody>
</table>

- The “Matrix” is a comprehensive curriculum for neurological surgery
- Reflects RRC case categories and ABNS written examination question content categories
- SNS CoRE, Curriculum Subcommittee
The ACGME Milestones were conceived as a method for the development of observable developmental steps toward independent practice. Specialty-specific Milestones were organized under the 6 ACGME domains of competency and were developed by working and advisory groups with the support of ACGME.

- Observable developmental steps from Novice to Expert/Master (based on Dreyfus model)
- Organized under the six domains of clinical competency
  - Set aspirational goals of excellence (Level 5)
  - Provide a blueprint for resident/fellow development across the continuum of medical education
- Working and Advisory Groups were anchored by members of each specialty, including board members, program directors, Review Committee members, national specialty organization leadership, and residents/fellows - with ACGME support
- General competencies were translated into specialty-specific competencies
FIGURE 6. Milestones are envisioned as a means of tracking progress in an individual’s educational progress toward independent practice from novice to proficiency based on time in training, practice, and experience (Dreyfus model).
**FIGURE 7.** Specific Milestone elements (9 in total) are presented under the General Competency of Patient Care and the subcompetency of acquiring a history. Each level (1-5) represents a set of Milestones, which, in the aggregate, document developmental progression. The goal for residency education is Level 4, with Level 5 representing advanced residency/fellowship training.
**FIGURE 8.** An example of a Neurosurgery Milestone document. This relates to Medical Knowledge (MK) of Brain Tumors. Each level has a set of Milestones. The partial accomplishment of the level is indicated by a check immediately below the element, and full completion, by a check under the line between it and the next level.
In the first iteration of the Neurosurgical Milestones, there are 8 Medical Knowledge (MK) Milestone sets, 8 Patient Care (PC) Milestone sets, and 8 non-medical Milestone sets (two each for Interpersonal and Communication, Professionalism, Systems-Based Practice, and Practice-Based Learning).

**ACGME Milestones**

- **8 Medical Knowledge**
  - Brain tumor, Critical Care, Epilepsy and Movement Disorders, Pain and Peripheral Nerve, Pediatric Neurosurgery, Spine (X2), Vascular

- **8 Patient Care**
  - Brain tumor, Critical Care, Traumatic Brain Injury, Epilepsy and Movement Disorders, Pain and Peripheral Nerve, Pediatric Neurosurgery, Spine, Vascular

- **8 Non-medical**
  - Interpersonal and Communication (Relational, Technology), Professionalism (Compassion, Accountability), Systems-Based Practice (Economics, Safety and Systems), Practice-Based Learning (Life-long Learning and Improvement, Research)
FIGURE 10. The Matrix curriculum can be looked at as a roadmap to the goal of neurosurgical education, whereas the Milestones would be more akin to GPS tracking.
FIGURE 11. The neurosurgery Web Portal will initially integrate the Matrix curricular elements with the ACGME Milestones and provide Milestone-specific linkage to educational material from CNS, AANS, and other sources.
FIGURE 12. A user of the Web Portal will be able to select a Milestone and pursue educational material linked specifically to that element. The example shown is from the Neurosurgery Critical Care Milestone Medical Knowledge set. For level 1, the first Milestone in that set is: “Describes intracranial pressure (ICP), cerebral perfusion pressure (CPP), and cerebral blood flow (CBF).”
FIGURE 13. Navigation to information related to that Milestone can be specifically acquired by clicking on the link.

- Describes intracranial pressure (ICP), cerebral perfusion pressure (CPP), and cerebral blood flow (CBF) physiology
FIGURE 14. The user will then link to the Matrix elements related to that Milestone, and then can search each Matrix element for relevant resources.

• **C5. Describe the pathophysiology and clinical presentation of different types intracranial herniation and basic cerebral physiology (CO2 reactivity, autoregulation)**

• **C9. Interpret ICP, CPP, SjvO2, and PbtO2 data and manage abnormalities in these parameters**

• **N2. Insert and understand the indications and limitations of intracranial pressure monitoring devices including ventriculostomy catheters and parenchymal devices, and devices for monitoring brain oxygenation, biochemistry, blood flow, including jugular bulb catheters**

• **N3. Know indications for and be able to carry out the placement of intracranial pressure monitors and ventriculostomies and be able to manage these devices. Also be able to assess cerebral autoregulation at the bedside**
FIGURE 15. Educational content linked to the Milestone will be found from existing web resources from the AANS, CNS, and SNS.

- **C5.** Describe the pathophysiology and clinical presentation of different types intracranial herniation and basic cerebral physiology (CO2 reactivity, autoregulation)

- Click for content

  - American Association of Neurological Surgeons
    - Neurotrauma and Critical Care
  
  - Congress of Neurological Surgeons
    - University of Neurosurgery
  
  - Society of Neurological Surgeons
    - ICP Management
FIGURE 16. The Web Portal is being designed not only to track progress through residency and fellowship training, but also to serve as a dossier for life-long practice. This will serve the needs of later Board Certification, recognition of focused practice (RFP), and Maintenance of Certification.