

GW170817: a gravitational wave signal observed by the LIGO and Virgo detectors on 17 August 2017. **GRB 170817A**: a short gamma-ray burst detected by the Fermi and INTEGRAL spacecraft 1.7 seconds after the GW signal ended

The neutron star merger event is thought to result in a kilonova, characterized by a short gamma ray burst followed by a longer optical "afterglow" powered by the radioactive decay of heavy r-process nuclei.



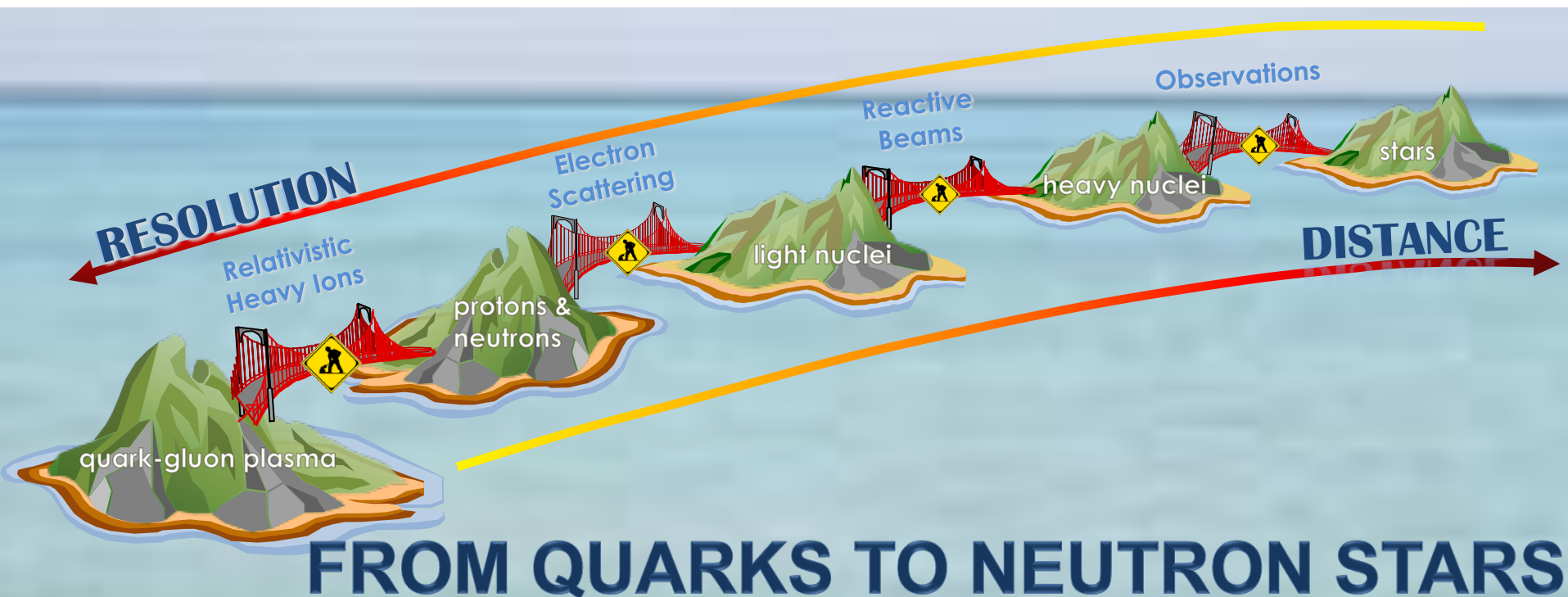
A total of 16,000 times the mass of the Earth in heavy elements is believed to have formed, including approximately ten Earth masses just of the two elements gold and platinum.



The paper describing the multi-messenger observations is coauthored by almost 4,000 astronomers (about one-third of the worldwide astronomical community) from more than 900 institutions, using 70 observatories on all seven continents and in space.

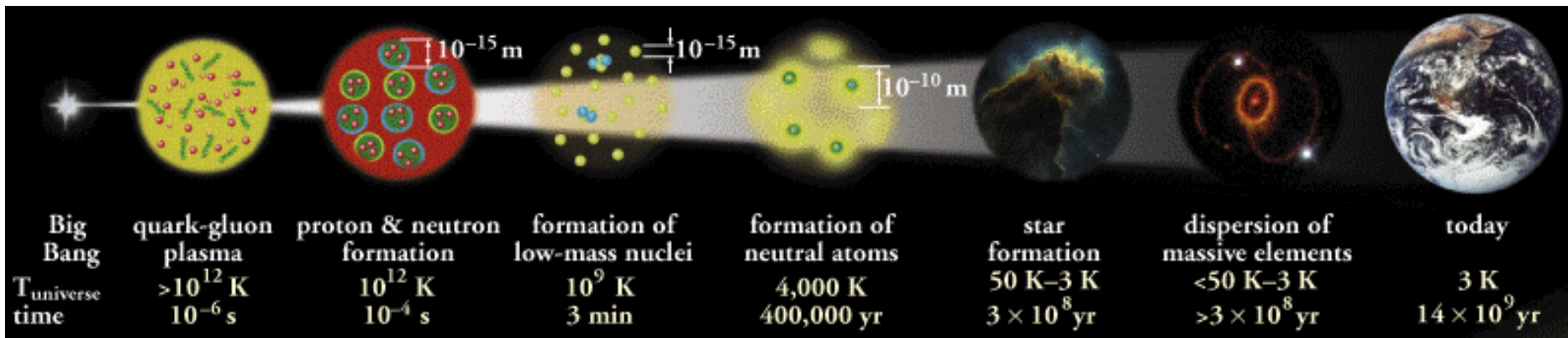
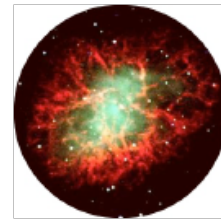
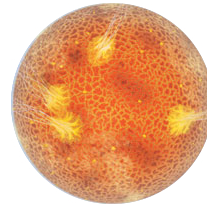
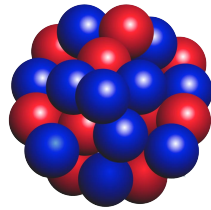
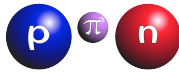
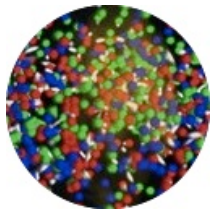
Subfields of nuclear physics

- Nuclear structure, whose goal is to build a coherent framework for explaining all properties of nuclei and nuclear matter and how they interact;
- Nuclear astrophysics, which explores those events and objects in the universe shaped by nuclei and nuclear reactions;
- Hot QCD, or relativistic heavy ions, which examines the state of melted nuclei and with that knowledge seeks to shed light on the nature of those quarks and gluons that are the constituent particles of nuclei;
- Cold QCD, or hadron structure, which explores the characteristics of the strong force and the various mechanisms by which the quarks and gluons interact and result in the properties of the protons and neutrons that make up nuclei;
- Fundamental symmetries, those areas on the edge of nuclear physics where the understandings and tools of nuclear physicists are being used to unravel limitations of the Standard Model and to provide some of the understandings upon which a new, more comprehensive Standard Model will be built.



Nuclear Physics in the Universe:

The Big Bang timeline, from inflation to quark soup to the birth of the light nuclei to the formation of atoms and gravitationally bound structures.

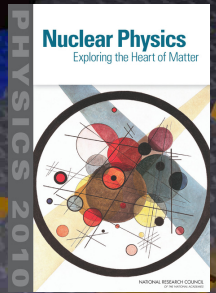
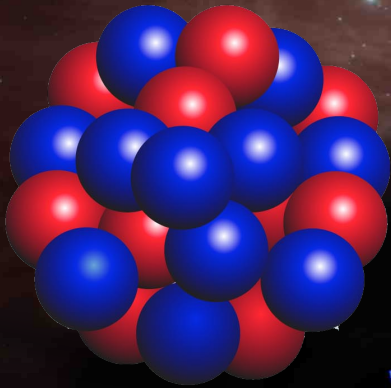


<http://www.lbl.gov/abc/wallchart/>

Image: Particle Data Group/Lawrence Berkeley National Laboratory

The Nuclear Landscape and the Big Questions

- Where do nuclei and elements come from?
- How are nuclei made and organized?
- What are practical and scientific uses of nuclei?



TIMESCALE

→ from QCD transition (color singlets formed; 10 ms after Big Bang) till today (13.8 billion years later)

DISTANCE SCALE

→ from 10^{-15} m (proton's radius) to ~12 km (neutron star radius)

The scientific agenda (questions that drive the field)

PERSPECTIVES ON THE STRUCTURE OF ATOMIC NUCLEI

- What are the limits of nuclear existence and how do nuclei at those limits live and die?
- What do regular patterns in the behavior of nuclei divulge about the nature of nuclear forces and the mechanism of nuclear binding?
- What is the nature of extended nucleonic matter? What are its phases?
- How can nuclear structure and reactions be described in a unified way?
- How can the symbiosis of nuclear physics and other subfields be exploited to advance understanding of all many-body systems?

NUCLEAR ASTROPHYSICS

- How old is the universe?
- How did the elements come into existence?
- What makes stars explode as supernovae, novae, or X-ray bursts?
- What is the nature of neutron stars?
- What can neutrinos tell us about stars?

EXPLORING QUARK-GLUON PLASMA

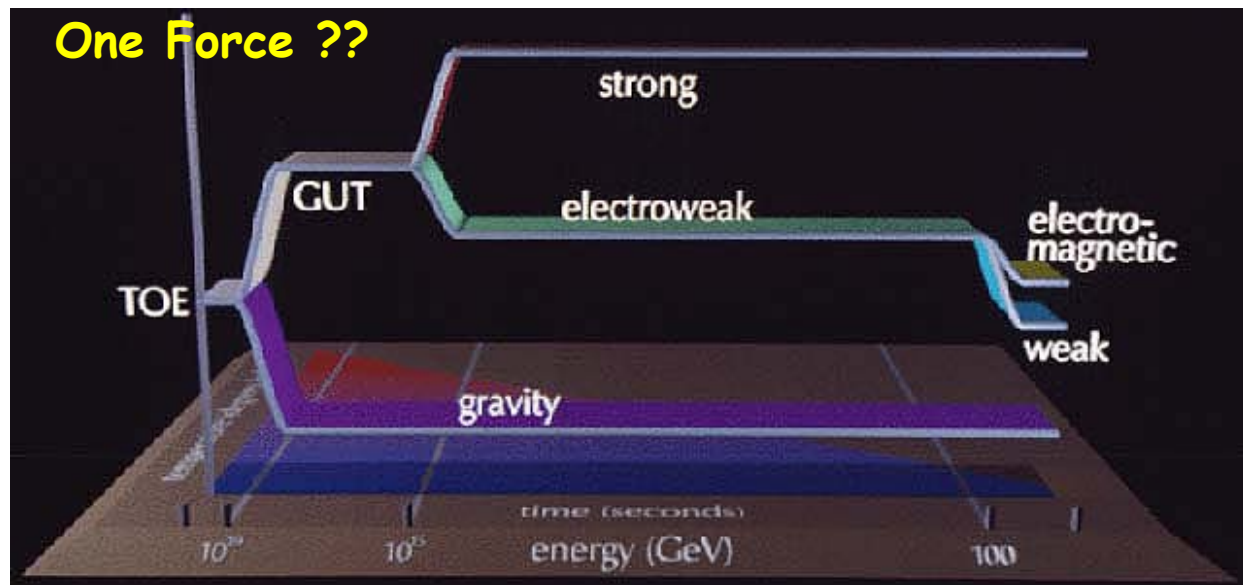
- What are properties of near-perfect liquid QGP
- What is the origin of confinement?
- What are the properties of the QCD vacuum? What is the origin of chiral symmetry breaking?
- What are the experimental signatures for a transition to new phases in relativistic heavy-ion collisions?
- What are the implications for the analogous epoch in the Big Bang?

THE STRONG FORCE AND THE INTERNAL STRUCTURE OF NEUTRONS AND PROTONS

- What are the internal structural properties of protons and neutrons and how do those properties arise from the motions and properties of their constituents?
- How do those properties change when protons and neutrons are combined into complex nuclei?
- Can QCD describe the full spectrum of hadrons in both their ground and excited states?
- How do the nucleonic models emerge from QCD?

FUNDAMENTAL SYMMETRIES

- What is the nature of the neutrinos, what are their masses, and how have they shaped the evolution of the cosmos?
- Why is there now more visible matter than antimatter in the universe?
- What are the unseen forces that were present in the dawn of the universe but disappeared from view as it evolved? Once very hot and very homogeneous, the universe now displays a preferred “handedness” and so the existence of lost forces.
- What are the low-energy manifestations of physics beyond the Standard Model? How can precision experiments in nuclear physics reveal them?

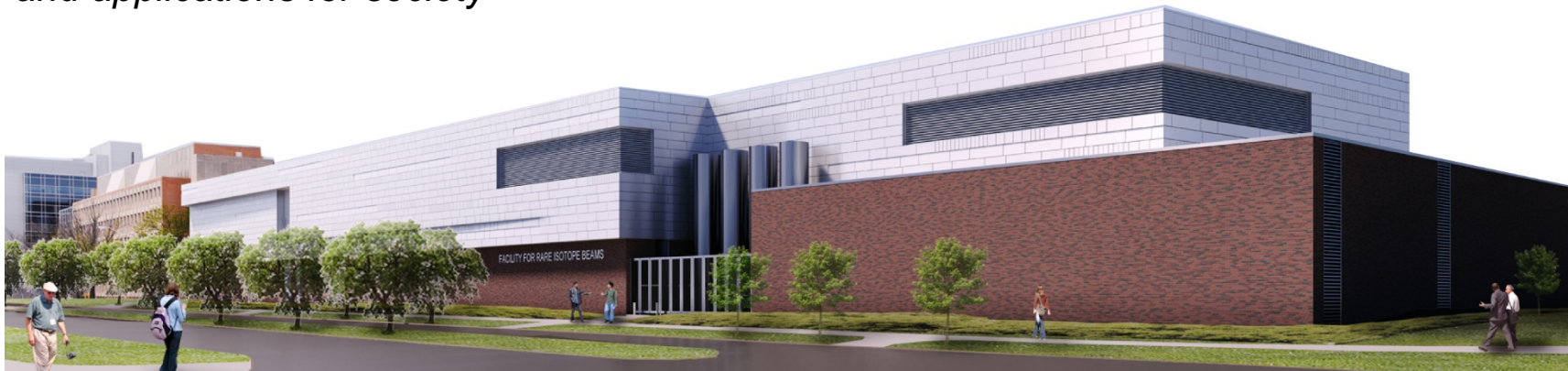


Facility for Rare Isotope Beams at MSU



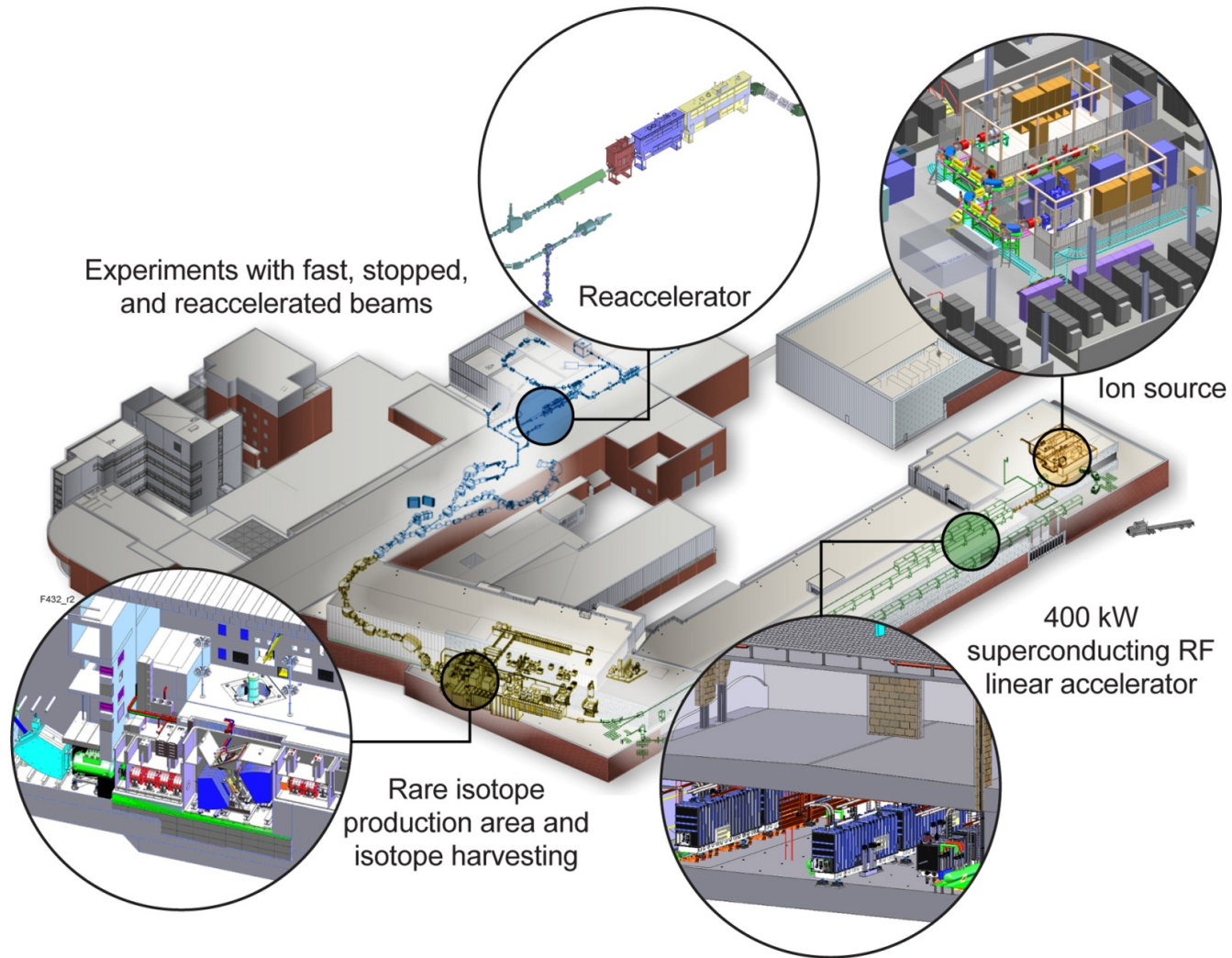
- FRIB will be a \$730 million national user facility funded by the Department of Energy Office of Science (DOE-SC), Michigan State University, and the State of Michigan
- FRIB Project completion date is June 2022, managing to an early completion in fiscal year 2021
- FRIB will serve as a national user facility for world-class rare isotope research, and builds on more than 50 years of nuclear science expertise developed at MSU

FRIB will enable scientists to make discoveries about the properties of these rare isotopes in order to better understand the physics of nuclei, nuclear astrophysics, fundamental interactions, and applications for society



<http://www.frib.msu.edu/news/photo-gallery/four-camera.html>

World's Most Powerful Rare Isotope Research Facility



The Science is in the FRIB Logo

Properties of atomic nuclei

- Develop a predictive model of the atomic nucleus

Nuclear processes in the cosmos

- Origin of the elements
- Stellar explosions
- Neutron stars

Societal applications and benefits

- Medicine, energy, materials, national security

Tests of laws of nature

- Tiny effects amplified in certain nuclei; complementary information to collider data, e.g., at LHC



FRIB

Middle circle:
FRIB capabilities (fast, stopped, reaccelerated, and harvested beams) that match the science program

Der Staaten Anfuhr in hinfur Filianzen gegen Orients, bei dem Lande Indien liegt.

AMERI



MICHIGAN TERRITORY.

SITUATION, BOUNDARIES, AND EXTENT.

Michigan territory is situated between 41° 31' and 49° 37' N. lat. and 87° 22' and 119° 37' W. long. It is bounded north by lake Superior, east by the States of Ohio, and west by the Indiana territory, to the north and east its boundary is the same with that of the United States. It is 250 miles long from north to south, and about 300 broad, containing about 44,600 square miles.

FACE OF THE COUNTRY, SOIL, &c.

The country along the eastern shore of lake Michigan, and extending into the interior as far as the dividing ridge consists of sand hills, sometimes covered with a few scattered trees, and a scanty vegetation, but generally bare, and thrown by the wind into a thousand fantastic shapes. The whole of this tract originally formed part of a single tract of land, and as the sea gradually advanced, the water gradually retreated, and the land gradually increased, as every stone thrown up now evidences it. The eastern part of the territory, consisting of lands ceded by the Indians, has never of course been brought into cultivation. It is now ascertained to be a fertile region, well fitted for wheat and fruit of all kinds. It is generally level, and watered by fine rivers, and is well adapted for the transportation of produce from the interior. The lands on Saginaw river, and bay, which were ceded by the Indians in 1763, are especially fertile, and of an excellent quality, and beautifully situated. The lands on the bank of the river St. Mary are also very fertile.

LAKE, BAYS, AND RIVERS.

Michigan lake is 292 miles long, 43 broad, and 802 in circumference, containing 22,000 square miles, or 42,300 square miles. On the northeast it communicates with lake Huron, through the straits of Michilimackinac, and on the north-west it branches into two large bays, one called Saginaw, and the other Huron bay. The latter bay is a large bay, and is full of various kinds, particularly trout, and is of a large size and excellent quality, and numerous are found in its bays and rivers.

The north end of the lake 20 miles a south-west direction, is a narrow strait, and is called St. Mary's. It is a narrow strait, and is 14 or 20 miles long. At the mouth of the lake 20 miles a south-west direction, is a narrow strait, and is called St. Mary's. It is a narrow strait, and is 14 or 20 miles long. At the mouth of the lake 20 miles a south-west direction, is a narrow strait, and is called St. Mary's. It is a narrow strait, and is 14 or 20 miles long.

The river St. Clair is a large stream which discharges itself into the southern extremity of Saginaw bay. The river St. Clair is a large stream which discharges itself into the southern extremity of Saginaw bay. The river St. Clair is a large stream which discharges itself into the southern extremity of Saginaw bay.

ANIMALS.

No state in the union is so beautifully supplied with wild game, fish, and aquatic birds. The latter frequent the rivers running into lake Michigan, lacustrine waters, the deer, and beaver are also found in the forests. The trout of Michilimackinac have a superior quality, they weigh from 10 to 15 pounds, and are taken in all seasons. White fish are caught in prodigious numbers in the river Detroit and lake St. Clair, as well as at the falls of St. Mary. Sturgeon are common in lakes Erie, St. Clair, Huron, and Michigan.

CLIMATE.

The climate is healthy, and much milder than that of the Atlantic states in the same latitude. In the western part it resembles that of the western counties of New York and Pennsylvania, towards the southern boundary it is much milder, but, upon the coast of lake Huron, and even that of St. Clair, it is more severe.

CIVIL DIVISIONS AND POPULATION.

The territory is divided by lake Michigan into two parts. The eastern and much the largest division is a province, bounded on three sides by lakes Michigan, Huron, St. Clair, and Erie, and on the north side by the states of Ohio and Indiana. The western division is a province, bounded on three sides by lakes Michigan, Huron, St. Clair, and Erie, and on the north side by the states of Ohio and Indiana. The western division is a province, bounded on three sides by lakes Michigan, Huron, St. Clair, and Erie, and on the north side by the states of Ohio and Indiana.

COUNTY.

Wayne.....174
Macomb.....208
Oakland.....219
Michilimackinac.....219
Berrien.....222
Crawford.....222
Monroe.....222

TOWNS AND PORTS.

Detroit, the capital of the territory, is in Huron river, 2 miles from lake St. Clair. It was settled as early as 1682, by the French from Canada, for the purpose of the fur trade. At present it stands in a healthy situation, and is one of the most important military posts on the upper lakes. In 1818 the amount of shipping was 649 tons. The fort is a regular work, with parapets and bastions, and surrounded by palisades, a deep ditch, and glacis. Population in 1820, 1427.

Michilimackinac, commonly called Mackinac, is an island of the same name, in the straits of Michilimackinac. The island is about 9 miles in circumference, and the village is on the southwest side of it, on a small point, which is surrounded with a steep cliff, 130 feet high, on the top of the cliff stands the fort. Behind the fort, at the distance of half a mile, is another summit, 100 feet high, and 200 feet above the level of the lake, on which fort Huron is situated. From this spot there is an extensive prospect into lake Huron and lake Michigan. During the winter, Mackinac is the resort of many Indians and fur traders.

The present fort is on a low sandy spit, half a mile from the mouth of the river, but a new strong fort is now constructing on a beautiful rising ground on the south side of the river, 2 miles above the old fort.

Fort Meigs is a military post on St. Clair river, and defends the entrance into lake Huron. The position of the fort at St. Mary is a military and trading post, being at the head of deep navigation on the great lakes, and the grand thoroughfare of Indian communication for the upper continent, as far as the great rivers, all the fur trade of the northwest being compelled to pass through it. The government of the United States has resolved to strengthen this post, and to have a garrison of 1000 men, and to have a garrison of 1000 men, and to have a garrison of 1000 men.

GEOGRAPHICAL, STATISTICAL, AND HISTORICAL MAP OF MICHIGAN TERRITORY.

MICHIGAN TERRITORY. No. 36.

GOVERNMENT.

The legislative power is vested in a governor and a supreme court, composed of three judges, all appointed by the president and senate of the United States. The executive power is vested in a governor and the judicial in the three judges, and in such civil magistrates on the different districts as the governor may appoint. There is at present no Judge of probate in any district, and justice of the peace, who hold jurisdiction of personal actions in cases where the damages do not exceed one hundred dollars. The superior court has original jurisdiction in all other cases. The ministerial officers are a marshal for the territory, and a deputy marshal for each district.



Finlayson 1822