

## India's missiles:

(This is a near exhaustive list of operational missiles of India, however, the focus should be on those missiles which are in news.)

### Surface-to-Air Missiles

A surface-to-air missile (SAM), or ground-to-air missile (GTAM) is a weapon designed to be launched from the Earth to destroy enemy aircraft or other missiles and can be considered as an anti-aircraft defence system in modern armed forces.

- **Trishul**
  - Trishul missiles are short-range surface to air missiles with an operational range of 9km.
- **Akash Missile** ○ Presently, there are three variants at different stages of development, Akash-1S, Akash Mark-II, Akash-NG. The Akash -1S can travel up to a distance of 18 to 30 km, while the Akash Mk-II and Akash-NG can travel 35 to 40 km and more than 50 km, respectively.
- **Barak 8** ○ The long-range Indo-Israeli surface to Air Barak 8 Missile can travel up to a distance of 100 km to hit the target with Mach 2 speed.

### Surface-to-Surface Missiles

Surface-to-surface missiles are launched from the ground to strike land or sea targets. They may be fired from hand-held or vehicles, from a ship or ground installations. They are often enabled with a rocket engine or sometimes fired by an explosive charge since the launching platform is typically stationary or moving.

- **Agni-I** ○ A medium-range ballistic missile that can travel a distance of 700-1250 km to hit its target. The missile can reach Mach 7.5 speed. It is a singlestage missile that was developed after the Kargil War by the DRDO.
- **Agni-II**
  - It is the second strategic ballistic missile of the Agni family envisaged to be the mainstay of the Indian missile-based strategic nuclear deterrence. An Intermediate-range ballistic missile, Agni-II can reach a distance of 2,000–3,000 km.
- **Agni-III**
  - It is an Intermediate-range ballistic missile that can travel a range of 3,000 km, it was deployed to service in 2011 and can reach targets deep inside neighbouring countries.
- **Agni-IV**
  - Designed by the DRDO and inducted in service in 2013, The Agni-IV is an Intermediate-range ballistic missile that can reach a distance of around 4,000 km at Mach 7 speed.
  -

- **Agni-V**
  - The Agni-V missile is an Indian nuclear-capable intercontinental ballistic missile developed by the DRDO.
  - It uses a **three-stage solid fuelled engine**, is capable of striking targets at ranges up to 5,000 kilometres with a very high degree of accuracy.
  - It is a “canisterised” missile.
  - A canister for a missile serves a dual function which provides an environmental container and a launching tube. Canister can provide both hot and cold launch.
    - A launch system can be either hot launch, where the missile ignites in the cell, or cold launch, where the missile is expelled by gas produced by a gas generator which is not part of the missile itself, and then the missile ignites.
  - A canisterised missile can be stored for a longer period and transported all across the country as per operational requirements.
- **Agni Prime**
  - Agni Prime’ is a short-range (surface to a surface) ballistic missile that will have a range of 1000 km to 1500 km and will have advanced features in agility and road mobility. O
  - It can carry a payload of around 1,000 Kg or a nuclear warhead. ○ It is a two-stage canisterised solid propellant ballistic missile.
  - It is predecessor of Agni 1.
- **Prithvi II** ○ A Short-Range Ballistic Missile, Prithvi II can travel a distance of 350 km. The missile is developed by the DRDO
- **Shaurya**
  - The Shaurya missile is a canister launched hypersonic surface-to-surface tactical missile developed by the DRDO for use by the Indian Armed Forces. The missile can reach a distance of 750 to 1,900 km to destroy its target.

## Air-to-air Missiles

Air to Air Missiles (AAM) is a missile fired from an aircraft with a motive to damage another aircraft or any airborne object. AAM is either solid fuelled or sometimes liquidfuelled. It evolved from unguided air to air rockets used during World War-I.

- **MICA**
  - MICA is an anti-air multi-target, all-weather, fire-and-forget short and medium-range missile system encompassing a range of 500 m to 80 km reaching Mach 4 during its deployment.
- **Astra Missile** ○ Developed indigenously by the DRDO, Astra is an all-weather beyondvisual-range active radar homing air-to-air missile encompassing a range of 80-110 km reaching the Mach 4.

•

- **Novator K-100**

- A Russian-made medium-Range air-to-air missile can be deployed to hit targets in the range of 300–400 km with a Mach 3.3 speed.

## **Cruise Missiles**

A cruise missile is guided to its target by an onboard computer. It is a guided missile used against terrestrial targets, that remain in the atmosphere and flies the major portion of its flight path at an approximately constant speed. Cruise missiles are designed to deliver a target warhead over long distances with high precision.

- **BrahMos Supersonic Cruise Missile** ○ BrahMos missiles are designed developed and produced by BrahMos Aerospace, a joint venture company set up by the DRDO and Mashinostroyeniya of Russia. It is named after Brahmaputra river and Moskva River of Russia. The BrahMos supersonic cruise missile can cover a range of 290 km reaching the Mach 2.8 to 3 Mach speed.
- **Nirbhay**
  - The Nirbhay subsonic cruise missile can reach a maximum range of 1,000 to 1500 km to destroy its target with a Mach 0.8 speed. The missile can be launched from multiple platforms and is capable of carrying conventional and nuclear warheads.

## **Submarine-launched ballistic missile**

A submarine-launched ballistic missile (SLBM) is a ballistic missile capable of being launched from submarines. Each missile carries a nuclear warhead and allows a single launched missile to strike several targets. Modern submarine-launched ballistic missiles are closely related to intercontinental ballistic missiles which can be deployed to reach a range of over 5,500 km.

- **Sagarika (K-15)**
  - Sagarika (K-15) is an Indian submarine-launched ballistic missile that can reach a range of 750 km that was designed for retaliatory nuclear strikes.
- **K-4 Ballistic Missile** ○ The K-4 Ballistic Missile is a nuclear-capable Intermediate-Range submarine-launched ballistic missile developed by the DRDO to arm the Arihant-class submarines. The missile has a maximum range of 3,500 km.
- **K-5 Missile** ○ The K-5 is a submarine-launched ballistic missile under development by the DRDO. The missile has a planned range of 5,000 km and will be equipped with Arihant-class submarines and is considered to be the fastest missile in its class.

## **Anti-Tank Missile**

An anti-tank guided missile (ATGM) is a guided missile primarily designed to hit and destroy heavily armoured military vehicles, which can be transported by a single soldier,

to larger tripod-mounted weapons, which require a team to transport and fire, to vehicle and aircraft mounted missile systems.

- **Amogha-1**
  - The Amogha-1 is an ATGM with a range of up to 2.8km. It is under development by Bharat Dynamics at Hyderabad. It is the maiden missile designed and tested by Bharat Dynamics and will be produced in two versions. The land version has already been tested.
- **Nag Missile** ◦ The Nag missile, also known as 'Prospina' for the land-attack version is an Indian third-generation, all-weather, fire and forget, an anti-tank guided missile with an operational range of 500m to 20km and ten-year maintenance-free shelf life.

### Anti-ballistic missiles

An Anti-ballistic missile is a surface to air missile designed and manufactured to counter ballistic missiles (Missile defence). Ballistic missiles are used to deliver nuclear, chemical, biological or conventional warheads in a ballistic attack.

- **Prithvi Air Defence (PAD)** ◦ The Prithvi Air Defence (PAD) is a two-stage liquid and solid-fueled ballistic missile defence high altitude interceptor based on the Prithvi missile. The two-stage interceptor is 10 meters tall and is said to reach a maximum altitude of 80km.
- **Prithvi Defense Vehicle (PDV)** ◦ The Prithvi Defense Vehicle (PDV) is an exo-atmospheric interceptor missile designed and manufactured to shoot down short-medium, and intermediate-range ballistic missiles in their terminal phase by intercepting with a hit-to-kill approach.

### Anti-Satellite Missile

- **A-SAT Missile** ◦ In March 2019, India joined an exclusive club of countries that has the capability to hit a target in space as it tested the anti-satellite missile via 'Mission Shakti'. This test, which came just months after India completed its fully operational nuclear triad (being able to launch nuclear warheads from air, land and sea), made India just the fourth country, after the US, Russia and China to be able to do so.

**Source:** <https://www.republicworld.com/india-news/general-news/missiles-of-india-a-comprehensiveoverview-of-indias-deadly-missile-arsenal.html>

### Drone Regulation

Drones or unmanned aerial vehicles (UAVs) are: "Powered, aerial vehicles that do not carry a human operator, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload."



### **Applications of UAVs**

- Damage assessment of property and life in areas affected with natural calamities, surveys, critical infrastructure monitoring.
- Security function: Drones are used by Armed Forces for tactical purposes at border.
- Surveillance and Crowd Management: It is used for effective and smooth conduct of events like Kumbh Mela etc.
- Monitoring of wildlife: UAV are deployed these days for better counting and guarding unreachable region.
- Agriculture: SENSAGRI (SENSOR based Smart AGRiculture) is a drone based crop and soil health monitoring system using hyperspectral remote sensing (HRS) sensors.
- Mode of Delivery: Many e-commerce companies are using it for delivering their product like Amazon.
- Other uses: For surveys, infrastructure monitoring, commercial photography, aerial mapping etc.

### **Concerns regarding use of drones**

- Potential threat: Its use poses a security threat, and has the potential for invading privacy.
- The airspace over Indian cities already has a high density of aircraft traffic and unregulated use of drones poses a grave threat for air collisions and accidents.
- Drone traffic management: will require planned research and practical experimentation. Small drones fly at low altitudes and are more susceptible to changing weather conditions. Strong winds and rains can easily knock them off course, out of their designated operating zones.
- Drones as weapons: They are considered a cost effective weapon system with no risk to operators. Thus, they are being portrayed as weapons of future warfare.
- Drones are being used by terrorists, criminals, drug cartels and other antisocial groups for their attacks.

Therefore, government has come up with **Drone rules 2021 under Aircraft Act, 1934** which is built on a premise of trust, self-certification and nonintrusive monitoring.

### **Salient Features:**

- Classification of Drones: Nano (upto 250gm), Micro (250gm – 2kg), Small (2kg – 25kg), Medium (25kg – 150kg), Large (>150kg)
- Air space has been partitioned into:

- Red zone denotes “no fly zone” (include airspace around airports; near international border, Vijay Chowk in Delhi; State Secretariat Complex in State Capitals, strategic locations/vital and military installations; etc.)
- Yellow zone is controlled airspace which signifies airspace requiring Air Defence Clearance or Air Traffic Control clearance.
- Green zone signifies unrestricted airspace zones. However, even for the Green zone, there is a need to get clearance from the Digital Sky Platform.
- Digital Sky Platform (<https://digitalsky.dgca.gov.in/>):
  - It is a software-based self-enforcement unmanned traffic management (UTM) system. ○ It is expected to facilitate registration and licensing of drones.
  - It also provides instant (online) clearances to operators for every flight. Thus India has a ‘No Permission-No Take off’ (NPNT) clause, which implies that a drone cannot be operated in Indian skies unless the regulatory permission is received through the Digital Sky Platform. ○ A process has been prescribed for drone operators to obtain Unique Identification Number (UIN).
- Unmanned Aircraft Operator Permit: It is a permit required by the owners of the drones to fly them which can be obtained from the Director General of Civil Aviation.
- The pilot also needs certification, requiring a remote pilot licence before operating a drone.
- Foreigners are currently not allowed to fly drones in India.
  - For commercial purpose, they need to lease the drone to an Indian entity who in-turn will obtain Unique Identification Number (UIN) and UAOP from DGCA.

## Dr Vikram Sarabhai

- Dr. Vikram Ambalal Sarabhai was an Indian astrophysicist who is considered as the Father of Indian Space Program.
- He worked on cosmic ray studies at the Indian Institute of Science in Bangalore, where he was mentored by Nobel Laureate Dr. C. V. Raman.

### Contributions in the development of space technology in India

- **Establishment of ISRO:** His vision and commitment led to the establishment of Indian National Committee for Space Research (INSCOSPAR), which was later re-christened as the Indian Space Research Organisation (ISRO) in 1969.
- He was appointed as the **Chairman of the Atomic Energy Commission of India** and was largely responsible for the establishment and development of India’s nuclear power plants.
- **Physical Research Laboratory (PRL):** In 1947, he returned to India and founded the Physical Research Laboratory (PRL) in Ahmedabad. PRL was

one of the first research institutes in India to work in the field of space sciences.

- **India's first rocket launching station:** Along with Dr. Homi Bhabha, Dr. Sarabhai set up India's first rocket-launching station at Thumba near Thiruvananthapuram. It led to the development of present day indigenous rocket launchers like SLV, PSLV, GSLV.
- **Development of Satellite programme:** He started a project for the fabrication and launch of an Indian Satellite. As a result, the first Indian satellite, Aryabhata, was put in orbit in 1975 from a Russian Cosmodrome.
- Further, the **Satellite Instructional Television Experiment (SITE)** was launched in 1976 based on his dialogue with NASA. The project helped India gain technical experience in the field of satellite communications and made available informational television programs to rural India.
- The lander of India's Chandrayaan-2, Vikram, was named after him, and so was the Vikram Sarabhai Space Centre (VSSC), ISRO's facility for rocket development in Thiruvananthapuram.

### Dr Hargobind Khurana

- He was born in Raipur village of Multan district, In 1969, he was awarded Padma Vibhushan.
- 1968 Nobel Prize for Physiology or Medicine (shared with Nirenberg and Holley) for interpretation of genetic code and its function in protein synthesis.
- He proved that genetic code consists of 64 different three-letter words, which told the cell where to begin reading the code and where to stop.
- Constructed the **world's first synthetic gene** paving the way for further advancements in the field of genetic engineering and biotechnology.
- He investigated **mutations in rhodopsin** that are associated with retinitis pigmentosa, **which causes night blindness**. Rhodopsin is a light-sensitive protein found in the retina of the vertebrate eye.
- Contributed to the **science of polymerase chain reaction (PCR)** tests, used to detect genetic material from a specific organism, like a virus.
- Discovered structure of **transfer-RNA, or tRNA** (small RNA molecule that participates in protein synthesis)

### Dr A P J Abdul Kalam

- He was an Indian scientist who also served as the 11th President of India from July 25, 2002 to July 25, 2007.
- Kalam and his team were successful in developing **India's first indigenous hovercraft which was named Nandi**. A hovercraft is an amphibious craft capable of travelling over land, water, mud, ice and other surfaces.

- The team of rocket engineers of which Kalam was a part, set up the **Thumba Equatorial Rocket Launching Station (TERLS)** in 1963. • He was project **director of India's first Satellite Launch Vehicle**.
- He was given the responsibility to lead the **Integrated Guided Missile Development Program (IGMDP)**. According to the instructions of then Defence Minister R. Venkataraman, four missiles were to be developed simultaneously as part of the program. After years of consistent hard work and immense dedication, India got her first range of ballistic missiles, the Prithvi, the Agni, the Aakash, and the Nag.
- The **Pokhran-II nuclear** tests were conducted during this period and Kalam played an intensive political and technological role in their success.
- He served as **first principal scientific advisor to government of India**.
- He is author of best selling work Wings of Fire, which has inspired millions.
- He was awarded Bharat Ratna in 1997.

### **Homi Jehangir Bhabha**

- He was the first person to become the Chairman of the Atomic Energy Commission of India.
- Bhabha is acknowledged as the father of Indian nuclear power.
- He envisaged the 3 staged nuclear program to effectively utilize thorium reserve of India.  
Bhabha was also the founding director of the Atomic Energy Establishment, Trombay (AEET) which is now named the Bhabha Atomic Research Centre
- He calculated the **cross section of electron-positron scattering**.
- He also helped in developing the **cosmic radiation's understanding**.
- He was instrumental in establishing the Tata Institute of Fundamental Research in Mumbai.
- Along with Dr. Homi Bhabha, Dr. Sarabhai set up India's first rocketlaunching station at Thumba near Thiruvananthapuram.
- He promoted nuclear energy control and also advocated for the prohibition of atomic bombs worldwide.
- He was also nominated for the Nobel Prize for Physics in 1951 and 1953–1956.

### **Visvesvaraya**

- Sir Mokshagundam Visvesvaraya was a civil engineer who also served as Diwan of Mysore (1912 to 1919).
- Sir MV was recognized for engineering the Krishna Raja Sagara Dam located in Mysore.
- Also, he was one of the Chief designing engineers for bringing up a system for flood protection in Hyderabad.
- He is credited for inventing 'automatic sluice gates' and 'block irrigation system' which are still considered to be marvels in engineering.
- He came up with an efficient way of filtering water through 'Collector Wells'



- In 1955, he was honored with Bharat Ratna.
- September 15 is celebrated as Engineers day in India, in his loving memory.

### **Meghnad Saha**

- Meghnad Saha's best-known work concerned the thermal ionisation of elements, and it led him to formulate the Saha Equation.
- This equation is one of the basic tools for interpretation of the spectra of stars in astrophysics.
- By studying the spectra of various stars, one can find their temperature and from that, using Saha's equation, determine the ionisation state of the various elements making up the star.
- He also invented an instrument to measure the weight and pressure of solar rays.
- He was also the chief architect of river planning in India.

### **Praful Chandra Ray**

He established Bengal Chemical and Pharmaceutical Works Ltd, India's first pharmaceutical company in 1901.

- His research included organic compounds containing sulphur, double salt, homomorphism and fluorination.
- His research included the discovery of the stable compound mercurous nitrite in 1896 while studying nitrite and hyponitrite compounds and their compounds.

### **Shanti Swaroop Bhatnagar**

- He was "father of research laboratories" in India.
- He was also the first Chairman of the University Grants Commission(India)
- In 1958, to honour his name and legacy, the Indian Council of Scientific and Industrial Research (CSIR) instituted the Shanti Swarup Bhatnagar Prize for Science and Technology for scientists who have made significant contributions in various branches of science.
- In 1940, the Board of Scientific and Industrial Research (BSIR) was formed for a period of two years and he was appointed as its Director. In 1941, he persuaded the government to set up an Industrial Research Utilisation Committee (IRUC) for further investment into industrial research.
- In 1942, the Council of Scientific and Industrial Research (CSIR) was formed and the BSIR and IRUC became its advisory bodies. In 1943, CSIR approved his proposal to establish five national laboratories.
- Post-independence, he was made the chairman of the CSIR and he became the first director general of the council. He established many

laboratories and mentored many great minds during his tenure as the head of the CSIR.

## **Ramanujan**

- With almost no formal training in pure mathematics, he made extraordinary contributions to mathematical analysis.
- Ramanujan was elected to the London Mathematical Society in 1917 and was elected a Fellow of the Royal Society for his excellent work on Elliptic Functions and the theory of numbers.
- Ramanujan made priceless contributions to several mathematical concepts like infinite series, continued fractions, number theory and mathematical analysis.
- He also made notable contributions like the hypergeometric series, the Riemann series, the elliptic integrals, the theory of divergent series, and the functional equations of the zeta function.
- He introduced a summation in 1918, now known as the Ramanujan sum which is currently used in signal processing, i.e., analysing, modifying and synthesising periodically repetitive signals such as speech, music, DNA sequences etc.
- He introduced the "mock theta functions" which are used today in 'String Theory' in theoretical physics. He is also credited for his work in 'Modular functions' which are used to reveal properties of Black Holes by astrophysicists.
- He discovered Hardy Ramanujan number i.e. 1729 which is the smallest number which can be expressed as the sum of two cubes in two different ways-  $1729 = 13^3 + 2^3 = 9^3 + 10^3$ .
- His birth anniversary 22 December is celebrated as National Mathematics day.

## **Women Scientists of India:**

**Anandibai Gopalrao Joshi** (1865-1887) First Indian female to study and graduate with a degree in western medicine from the United States (1886). She is believed to be the first woman to set foot on American soil from India

**Kadambini Ganguly (1861-1923)** The first Indian woman to get admission to Calcutta Medical College (1884), becomes India's first female doctor & practitioner (1886) of western medicine in the whole South Asia.

**Mary Poonen Lukose** (1886-1976) The first female Surgeon General in India, (1938). She became the first woman obstetrician of India.

**Bibha Chowdhary** (1913-1991) First woman high energy physicist of India and the first woman scientist at the TIFR (1948). The International Astronomical Union honored her by naming a white yellow dwarf star after her name.

**Edavaleth Kakkat Janaki Ammal** (1897-1984) Renowned botanist & plant cytologist, made significant contributions to genetics, evolution, phytogeography and ethnobotany. First Director of the Central Botanical Laboratory at Allahabad, 1952

**Kamala Sohonie** (1911-1998) First Indian woman to receive a PhD in a scientific discipline. She discovered the enzyme 'Cytochrome C' which plays an essential role in the electron transport chain occurring in plants, human and animal cells for energy synthesis.

**Asima Chatterjee** (1917-2006) The first woman to be awarded a Doctor of Science by an Indian University (Calcutta) in 1944. She was the first woman to be elected as the General President of the Indian Science Congress.

**Iravati Karve** (1905-1970) First Indian female anthropologist. She founded the Department of Anthropology at the University of Pune in 1963. She also held the post of the Vice-Chancellor of SNDT University.

**Debala Mitra** (1925-2003) First Indian archaeologist served as Director General of the Archaeological Survey of India, 1981. She explored and excavated several Buddhist sites.

**Purnima Sinha** (1927-2015) An Indian physicist who received a doctorate in physics under the guidance of Prof Satyendra Nath Bose. She did tremendous work in the field of x-ray crystallography of clay minerals.

**Rajeshwari Chatterjee** (1922-2010) Woman Engineer who pioneered research in microwave engineering. She is the first woman engineer at IISc who joined the Department of Electrical Communication Engineering (ECE).

**Anna Mani** (1918-2001) First woman to join the Meteorological department in Pune, 1948. Her major contributions are in the field of solar radiation, ozone and wind energy instrumentation.

**Kamal Ranadive** (1917-2001) Established India's first tissue culture research laboratory at the Indian Cancer Research Centre in Mumbai, 1960. She was among the first to recognise the connection between cancer susceptibility and the interaction between hormones and tumour virus.

**Tessy Thomas:**

- known as the 'Missile Woman' of India is the Director General of Aeronautical Systems and the former Project Director for Agni-IV missile in Defence Research and Development Organisation (DRDO).
- She is the first woman scientist to head a missile project in India.
- She has contributed in guidance, trajectory simulation and mission design at the DRDO. She designed the guidance scheme for long-range missile systems, which is used in all Agni missiles.

**Ritu Karidhal:**

- As Mission Director of the Chandrayaan-2 mission, Ritu Karidhal was feted for role in helming one of India's most ambitious lunar projects.
- She was responsible for detailing and the execution of the craft's onward autonomy system, that independently operated the satellite's functions in space and responded appropriately to malfunctions.
- Dubbed as the 'Rocket Woman of India' Ritu joined ISRO in 2007 and was also the Deputy Operations Director to India's Mars Orbiter mission, Mangalyaan.

**Muthayya Vanitha**

- She is the Project Director of Chandrayaan-2. She is the first woman to lead the interplanetary mission at ISRO.
- She was promoted from Associate Director to Project Director of the mission.
- She has occupied several roles such as leading the Telemetry and Telecommand Divisions in the Digital Systems Group of ISRO Satellite Centre, and has been the Deputy Project Director for several satellites including Cartosat-1, Oceansat-2, and Megha-Tropiques.

**Gagandeep Kang,**

- a virologist and scientist, is known for her interdisciplinary research in transmission, development, and prevention of enteric infections and their sequelae in children in India.
- She has been elected as a Fellow of the Royal Society (FRS), the first Indian woman scientist to receive this honour.
- she also national rotavirus and typhoid surveillance networks, established laboratories to support vaccine trials, and conducted phase one-three-

clinical trials of vaccines, a comprehensive approach that has supported two WHO prequalified vaccines made by two Indian companies.

- She is also investigating the complex relationships between infection, gut function, and physical and cognitive development, and seeking to build a stronger human immunology research in India.

### **Mangala Mani**

- The 'polar woman of ISRO', Mangala Mani is ISRO's first woman scientist to spend more than a year in the icy landscape of Antarctica.
- The 56-year-old had never experienced snowfall before she was selected for the mission. In November 2016, she was part of the 23-member team that went on an expedition to Bharati, India's research station in Antarctica.

### **Kamakshi Sivaramakrishnan**

- She is responsible for building the algorithm and the chip that is responsible for bringing information from Pluto as part of New Horizon mission.
- The chip on board the spacecraft collects signals and sends them back to the space station which is three billion miles away.
- Based in San Mateo, California, she has been building a complex algorithm to be more intuitive about how users interact with ads online, as well as across different interfaces – smartphones, tablets, laptops, etc.

### **Chandrima Shaha**

- Chandrima is a biologist and the first ever woman president of the Indian National Science Academy (INSA).
- She specialises in cell biology, and has conducted extensive research about the 'Leishmania' parasite which causes Kala Azar.